ASSESSMENT OF THE LOWER LABIAL GINGIVAL ARCHITECTURE AND ITS RELATIONSHIP WITH SKELETAL PARAMETERS AND LOWER INCISOR INCLINATION IN DRAVIDIAN POPULATION: AN IN-VIVO STUDY

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CERTIFICATE

This is to certify that this dissertation titled **"ASSESSMENT OF THE LOWER LABIAL GINGIVAL ARCHITECTURE AND ITS RELATIONSHIP WITH SKELETAL PARAMETERS AND LOWER INCISOR INCLINATION IN DRAVIDIAN POPULATION: AN IN-VIVO STUDY"** is a bonafide record of work done by **Dr. MAHALAKSHMI.D** under my guidance during her postgraduate study period 2009–2012.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the degree of **Master of Dental Surgery** in Branch V – Orthodontics and Dentofacial Orthopaedics.

It has not been submitted (partially or fully) for the award of any other degree or diploma.

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CONTENTS

INTRODUCTION

Assessment of the mucogingival status is considered to be a very important part of intra-oral examination, if orthodontic treatment is to be planned and rendered precisely from a biomechanical point of view.[37] Clinical observers and investigators have provided conflicting opinions about the effect of malocclusion on periodontium.[24] ***Ingervall et al*** [31] ***(1977)*** and ***Katz*** [35] ***(1978)*** had found no association between periodontal disease and crowded or malaligned teeth.' ***Buckley***[13] ***(1981)*** in his study of 300 subjects, showed that malocclusion was a co-factor in plaque retention and initiation of gingival inflammation.

The position in which a tooth erupts through the alveolar process and its eventual position in relation to bucco-lingual dimension of the alveolar process have a profound influence on the amount of gingiva that will be established around the tooth[1]. Accordingly, the tooth if erupted in a more labial position in close relationship to the mucogingival line, only minimal width or complete lack of gingiva will be found on the facial aspect. Also, the spontaneous change of the tooth position in the bucco-lingual direction that often occurs during the development and more importantly changes in tooth position during orthodontic treatment will exert a profound influence on the gingival architecture.[2,4]

The width of the attached gingiva is defined as the distance between the mucogingival junction and the projection on the external surface of the bottom of the gingival sulcus or periodontal pocket.[65]

The width of the attached gingiva plays a critical role of maintaining the the stability of the periodontium. The traditional roles attributed to this gingiva are because it is firm and resilient being attached to the underlying periosteum. The areas with narrow width of attached gingiva are reported to be more susceptible to recession during orthodontic tooth movement[43]. ***Wennstrom***[56] ***(1987)*** concluded that a narrow zone of attached gingiva apical to a localized recession is a consequence rather than a cause of the gingival recession[41].

Apart from the criteria of width of attached gingiva, the thickness of attached gingiva is also an important factor to be considered. Previously, ***Eger*** and ***Muller***[45] ***(1997)*** analysed the morphological characteristics of gingiva and concluded with evidence the existence of different gingival phenotypes as thick and thin phenotype that has been reported to respond differently to the orthodontic forces applied. ***Yared et al*** [61] ***(2006)*** evaluated the periodontal status of mandibular incisors after orthodontic proclination and found that gingival thickness had greater relevance to recession.

The nature of the skeletal pattern in the antero-posterior direction has a profound influence on the gingival parameters. In skeletal class III cases caused by orthognathic or retrognathic maxilla with mandibular prognathism the lower incisors tend to be in a more retroclined position. Whereas, in skeletal class II cases caused by orthognathic or prognathic maxilla with retrognathic mandible the lower incisors tend to be a in more proclined position[32,33]**.** ***Robinson et al***[47] ***(1972)*** noted the antero-posterior dental compensation present with mandibular prognathism. These compensations include tendencies towards proclination of maxillary incisors, retroclination of mandibular incisors and negative overjet.

It is suggested that mandibular incisors may be prone to recession than any other teeth in the dentition because of these compensations[42]. In cases of severe jaw imbalances, the teeth are inclined in such a way as to partially offset the discrepancy. ***Bibby*** [9] ***(1980)*** concluded that a compensation mechanism exists to reduce the anteroposterior discrepancy between the upper and lower apical bases, which is effected by retroclined lower incisors and proclined upper incisors in skeletal class III type of cases.

Furthermore contemplated factor is the vertical facial pattern and its relationship with the gingival parameters, the width and thickness of attached gingiva. ***Handelman***[28] ***(1996)*** studied about the anterior alveolus and its importance in limiting orthodontic treatment and concluded that a narrow alveolus was frequently noted around the mandibular incisors in subjects with high mandibular plane angle. These subjects may prone to iatrogenic phenomena i.e, bone loss, gingival recession and root resorption than those with average or low mandibular plane, thereby limiting the extent of tooth movement of the mandibular incisors in high angle cases[6].

There is insufficient evidence in literature regarding gingival parameters and its relationship to skeletal parameters and lower incisor axial inclination in our population.

Therefore the study was conducted in Dravidian population with the following aims and objectives ;

i) To measure the gingival parameters a) gingival width and b) gingival thickness of the lower labial gingiva in various skeletal malocclusion in antero-posterior direction and to determine the mean values in each skeletal group.

ii) To assess the gingival parameters in relation to the lower incisor inclination (IMPA).

iii) To assess the gingival parameters in relation to the vertical skeletal pattern (FMA).

iv) To identify the most profound influencing factor that determines the lower labial gingival architecture.

Review of literature

Tweed CH (1946)[52] defined the Frankfurt-Mandibular plane angle as the most significant value in skeletal analysis as it indicates the direction of the lower facial growth in the horizontal and vertical dimensions. The normal or standard of 22 to 28 degrees for this value projects a skeletal pattern with normal growth direction. An FMA greater than the normal range indicates excessive vertical growth, and an FMA less than the normal range indicates deficient vertical growth.

Tweed CH (1954)[53] stated that the normal variation of the inclinations of the mandibular incisors when related to the plane formed by the lower border of the mandible to range from 85 to 95 degrees with 90 degree being designated the norm. Therefore if FMA is accepted as 25 degree as the norm and a 90 degree inclination of the mandibular incisors as a norm, the norm for the third angle FMIA becomes 65degree.

Holdaway[29] (1956) discussed a compensatory mechanism which allows a good occlusion to be achieved in a subject with an acceptable facial balance in relation to a class II apical base. This relationship is achieved by the relative tipping of the upper and lower incisors.

Bowers[10] (1963) were the first to identify the adequate width required. The width of attached gingiva varied with each tooth and within each individual. In maxilla, the greatest width over lateral and central incisors particularly the laterals, decreased over the cuspid and first premolar, and increased slightly over the second bicuspid and molars. In mandible the broadest zone was seen over the centrals and laterals, particularly the laterals. It becomes extremely narrow in the cuspid and first bicuspid region, increased in the second bicuspid region, increased again in the first molar region, and decreased in the second molar region. The width of the attached gingiva increases with age. There were no differences found b/w females and males. Even with less than 1 mm, the tissue was still healthy, but without any attached gingiva the remaining tissue was inflamed. Factors affecting the width of attached gingiva were: Teeth malposition. (e.g: tooth in a labioversion had a narrower width of attached gingiva), high frenum and muscle attachment and gingival recession results in a narrow zone of attached gingiva.

Silness J Loe H[50] (1964) One hundred and twenty-one pregnant and sixty-one post partum patients were examined for occurrence and amount of soft and hard deposits on the teeth. Assessments of plaque were made by means of an index system proposed by the authors. Calculus was recorded according to Ramfjords method. The data obtained were correlated with data on the gingival conditions of the same patients. . They conclued that oral hygiene is adequately expressed by the presence and amount of soft debris (plaque index).

Zachrisson S, Zachrisson BU[64] (1972) conducted a longitudinal clinical study on gingival condition of 49 patients treated with fixed orthodontic appliance for an average of 19.1 months. A control group received no orthodontic treatment, no tooth brushing instructions or mouth rinsings. The results demonstrated that in spite of good cleaning and plaque index scores, most children developed generalized moderate hyperplastic gingivitis within 1 or 2 months after the placement of appliance. These changes persisted throughout the period of active orthodontic treatment. The main improvement in gingival health occurred only one month after the appliance removal. They concluded that the gingival changes from orthodontic treatment were transient and no permanent change to the periodontal tissues could be demonstrated.

Lang Niklaus P., Löe Harald[38] (1972) examined the width of the facial and lingual keratinized gingiva and determined how much gingiva is "adequate" for the maintenance of gingival health. After 6 weeks of supervised oral hygiene the gingival health of 1406 buccal and lingual surfaces in 32 dental students was assessed according to the criteria of the Gingival Index system. The width of keratinized gingiva was measured after the application of the Schiller IKI solution. Gingival exudation was measured on all buccal and lingual surfaces which had 2 mm or less of keratinized gingiva and in a randomly selected number of tooth surfaces with more than 2 mm gingiva. Only plaque free surfaces were scored. It was demonstrated that gingival health is compatible with a very narrow gingiva. However, in areas with less than 2 mm keratinized gingiva inflammation persisted in spite of effective oral hygiene. It is suggested that 2 mm of keratinized gingiva (corresponding to 1 mm attached gingiva in this material) is adequate to maintain gingival health.

Robinson SW, Spiedel TM, Isaacson RJ, Worms FW[47] (1972) noted the antero-posterior dental compensation present with mandibular prognathism. These compensations include tendencies towards proclination of maxillary incisors, retroclination of mandibular incisors and negative overjet.

Kloehn JS and Pfeifer JS[36] (1974) studied the response of the periodontium during and following orthodontic treatment on 50 consecutively treated orthodontic patients. They concluded that inflammation and hyperplastic changes in the gingiva which occurred during treatment was reversible upon appliance removal and the periodontium was in better health following treatment. They also confirmed that orthodontic treatment did not cause any irreversible periodontal destruction. There was a direct relationship between oral hygiene and periodontal disease.

Maynard, Oschsenbein[39] (1975) did a human study conducted in a private practice on children of 4 to 16 yrs. The purpose of this paper was to determine the prevalence of mucogingival problems in children and report on preventive therapy by free autogenous gingival grafts. A greater incidence of marginal gingivitis was observed in the permanent dentition when compared to the deciduous dentition. The narrower the zone of keratinized tissue in the permanent dentition, the more frequently marginal gingivitis was observed clinically. No mucogingival defects (inadequate keratinized tissue, recession, or labial root exposure) observed in the deciduous dentition, suggesting that mucogingival defects are a developmental problem of the permanent dentition. Mucogingival defects was observed clinically in 12-19% of patients. Insufficient keratinized tissue is primarily observed in chidren due to the eruption pattern of the permanent incisors and the width of the alveolar process. Free gingival graft (FGG) determined to hault the progression of an incipient mucogingival defect in children. Where orthodontic treatment is anticipated and coincidently insufficient keratinized tissue exists, a FGG should be performed prior to bucco-lingual tooth movement. Orthodontic correction of labiolingual tooth position are not recommended to correct a mucogingival defect because additional recession can occur. Grafts are recommended in children with 1mm or less of keratinized tissue. Grafts are not recommended in children when there is >2mm of keratinized tissue or when there is >1mm of attached gingiva.

Geiger AM and Wasserman BH[24] (1976) reported on the relationship of incisor inclination (cephalometric) to periodontal health to test the hypothesis that "abnormal incisor inclination might be associated with periodontal disease". The incisor angulations found in this study were grouped as i) less than 85º ii) 85º - 94º iii) 95º - 101º iv) more than 101º. Comparisons of incisor inclination were made with the periodontal destruction found on the labial and lingual surfaces of the incisors. The results showed that labial recession was significantly related to incisor inclination of less than 85º (linguoversion). Progressively less recession was found as the incisor angulation reflected a labial inclination. Lingual recession showed no relation to incisor inclination.

Ainamo J, Talari A[1] (1976) studied to determine the variation with age of the width of attached gingiva and the location of the mucogingival junction. The results showed that the measured anatomical width of attached gingiva does not differ between sexes but also that it increases significantly with age. The distance between the mucogingival junction and the lower border of the mandible did not increase with age. It was concluded that the mucogingival junction remains at a probably genetically predetermined location while the teeth move in an occlusal direction through adult life. In the absence of concurrent retraction of the gingival margin this results in an increase of the width of attached gingiva with advancing age.

Corelius M, Linder-Aronson S[17] (1976) studied the relationship between the inclination of lower incisors and different cranial reference lines in a group of 60 children (35 male and 25 female) between the ages 7 – 12 yrs. The results indicated a strong correlation between lower incisor inclination (IMPA) and the basal bone relationship (ANB). The inclination of the lower incisors may be increased or decreased in compensation for a large basal bone discrepancy between upper and lower jaws.

Goaslind GD, Robertson et al[26], (1977) studied gingival thickness in specific areas of healthy, free and attached gingiva. The subjects included 10 males with healthy gingiva. The gingival thickness on the facial aspect of selected maxillary and mandibular teeth were measured at two points. One at the depth of the sulcus and another midway between the depth of the sulcus and the mucogingival line. The results showed that the free gingival thickness averaged 1.56mm, the attached gingival thickness averaged 1.25 mm, and the total gingival thickness averaged 1.41 mm. The thickness in the mandibular free and attached gingiva and maxillary free gingiva increased from anterior to posterior. While thickness of maxillary attached gingiva remained constant. The thickness measured at depth of sulcus was directly proportional to free gingival width and the measurement midway between sulcus depth and mucogingival junction was inversely proportional to attached gingival width.

Miyasato et al[43] (1977) evaluated the gingival condition in areas of little and appreciable width of keratinized tissue. Contralateral or unilateral lower bicuspids of 16 people were examined. These areas had minimal (<=1mm) and appreciable (>=2mm) widths of keratinized gingiva on the mid buccal surface. 6 of the subjects had one lower biscuspid with a minimal width and a contralateral biscuspid with an appreciable amount of keratinized gingiva and the other 10 subjects had these two tissue types on adjacent bicuspids. Gingival exudate, gingival inflammation, sulcus depth, plaque scores and attached gingival measurements were taken. The 6 subjects with contralateral biscuspids were instructed to cease oral hygiene for 25 days. At days 0,4,7,11,14,18,21, and 25 measurements were retaken. In the group that stopped oral hygiene there was an increase in the plaque, gingival exudate and inflammation over the 25 day period. In this group however, there was no difference between the areas with minimal and appreciable widths of keratinized gingiva. The results showed that the gingiva with appreciable width and that with minimal width of keratinized tissue both displayed minimal amounts of gingival exudate and had no clinical signs of inflammation.

Ingervall b, Jacobson U, Nyman S[31], (1977) found that crowding of the teeth did not favour plaque accumulation on proximal surfaces and had only very slight effect on the degree of gingival inflammation. They concluded that the determining factor for gingival inflammation in crowded and non-crowded teeth is the presence and amount of plaque on the teeth rather than the position of the teeth in the arch

Sperry TP, Speidel T.M, Isaacson R J, Worms FW[51] (1977) doocumented the magnitude of dental compensations incorporated and retained in a group of orthodontically treated cases of mandibular prognathism. He noted that, as the mandibular incisors retroclined, their roots gained labial prominence, and some camouflaged incisors exhibited gingival recession. They cautioned that attaining proper skeletal-dental relationships is sometimes difficult to establish in patients with more severe skeletal-dental dysplasias and that one should exercise caution when treating Class III malocclusions nonsurgically.

Dorfman HS[19]. (1978) evaluated 1,150 fully treated orthodontic cases to determine changes in the width of keratinized gingiva relative to lower incisor tooth movement and to ascertain the incidence of mucogingival problems in orthodontic patients. In this group of patients 1.3 percent (sixteen) showed a decrease in the width of keratinized gingiva with either minimal movement or some labial movement of the mandibular incisors; 0.69 percent (eight) had an increase in keratinized gingival width concomitant with significant lingual positioning of the lower incisors. The salient point to be made is that with an initial minimal or inadequate width of keratinized gingiva (0 to 2 mm.), mandibular incisor tooth movement over a period of treatment could significantly affect the final quality of gingival health in the critical mandibular anterior region.

Katz[35] (1978) explored the relationships between periodontal disease and either (1) any of 8 existing orthodontic indices or (2) any of 41 individual cephalometric measures. The 486 subjects examined revealed no clinically significant associations between any of the disease measures and either the indices or the cephalometric measurements.

Boyd[11] (1978) reviewed and discussed the indications and timing of mucogingival therapy with respect to orthodontic intervention. The author stated that there are three conditions where a tooth in question should be evaluated orthodontically prior to any mucogingival procedure. When area of mucogingival involvement is related to a shearing effect of one tooth with another. In those areas where a tooth exhibits a mucogingival problem and is in labioversion, consultation with an orthodontist to determine if it is feasible to move the tooth lingually is advised. They have concluded that where mucogingival problems exist in the mixed dentition with no malposition of the involved teeth, surgical procedures designed to eliminate the problem should be performed to prevent further breakdown. If a malocclusion exists, consultation with an orthodontist would be advisable to find out what type of tooth movement and extractions can be anticipated. If a mucogingival problem exists coincidentally with a tooth in labioversion and the orthodontic treatment plan includes positioning the tooth lingually over basal bone then it would be advisable to perform the orthodontic therapy first.

Bibby[9], (1980) reported on incisor accommodation and assessed whether there was any consistent pattern operating. The results showed that the lower incisors tend to be retroclined in the protrusive cases of class III type while at the same time the upper incisors are proclined to meet them. This pattern is also seen in class II types but with one difference the upper incisors are relatively retroclined and the lower incisors have a similar and a slightly more anterior inclination than those in class I type. He concluded that a compensatory mechanism exists which allows the upper and lower incisos to be accommodated in a normal relationship regardless of the skeletal type. This compensatory mechanism is effected by both upper and lower incisors in skeletal class III and mainly by the upper incisors in the class II types.

Geiger[25] AM, (1980) reviewed the variations in gingival morphology having minimal attachment and frank localized pathosis. It is suggested that some cases of potential or actual mucogingival deficiencies may be improved by tooth movement. He concluded that orthodontic movement of abnormally positioned teeth or those subjected to trauma may contribute significantly to the repair of pathologic recession or prevent loss of attachment in cases with potentially inadequate attached gingiva.Some malaligned teeth with extensive localized recession may require surgical repair. Orthodontic treatment prior to surgery will encourage better hygiene and enhance the viability of the graft. In addition, any insult to newly grafted gingiva by orthodontic treatment subsequent to surgery will be avoided.

Buckley[13] LA (1981) examined 300 subjects, in which the incidence of gingival inflammation, plaque, calculus and malocclusion was correlated statistically to determine whether the distribution of these variables was due to more than chance. Based on the examination, the results showed that irregular, tilted, rotated and crowded teeth are related to gingival inflammation but are far less important than the extent of plaque and calculus deposits in the development of gingival inflammation.

Coatum G, Behrents, Bissada[16], (1981) studied the effects of orthodontic therapy on the width of keratinized gingiva and the length of clinical crowns on maxillary and mandibular canines and incisors. Teeth with less than 2mm of keratinized gingiva before orthodontic treatment showed a greater percentage of increased width (67.8%) than teeth with more than 2mm of pre-existing keratinized gingiva (44.8%). Teeth with less than 2mm of keratinized gingiva also showed a greater incidence of complete loss of keratinized gingiva (6.1%) compared to teeth with more than 2mm of pre-existing keratinzed tissue (0.1%). The incidence of complete loss of keratinized tissue was most common in the mandible. Statistically significant increases in the clinical crown during orthodontic treatment are not reflected in statistically significant decreases in the width of keratinized gingiva. Gingival clefts were not seen after orthodontic treatment in any area that had even the smallest width of keratinized gingiva prior to orthodontic treatment. Minimal amounts of gingiva are adequate to withstand the stresses of orthodontic treatment and maintain the integrity of the periodontium. An increase in the keratinized gingiva appeared to be related to bodily retraction and uprighting during treatment.

Wennestrom and Lindhe[55] (1983) analyzed the role of attached gingiva for the maintenance of periodontal health in sites with normal and reduced height of the supporting apparatus. The results showed that in sites exposed to careful plaque control measures gingival health could be established and maintained without sign of recession of the gingival margin or loss of attachment, independent of (1) presence or absence of attached gingiva, (2) width of keratinized gingiva or (3) height of the supporting attachment apparatus.

Following surgical excision of the entire gingiva, all buccal sites regained a zone of keratinized gingiva, but most sites were lacking attached gingiva. Furthermore, grafting of gingival tissue significantly increased the width of the keratinized and the attached gingiva but had no obvious effect on the position of the gingival margin or the level of the attachment.

Ellis E 3rd, McNamara JA Jr[20] (1984) identified the skeletal and dental relationships of adults who have class III malocclusions in 302 adult patients who had a class III molar and cuspid relationship. Ninety-four of the patients had had presurgical orthodontic treatment and 208 had not. The tracings were digitized, and the following sets of measures were analyzed: maxillary skeletal position; maxillary dentoalveolar position; mandibular dentoalveolar position; and mandibular skeletal position. In addition, the mandibular plane angle and lower anterior facial height were measured as an indicator of vertical facial dimensions. Although there was considerable variation among patients, the most common combination of variables was a retrusive maxilla, protrusive maxillary incisors, retrusive mandibular incisors, a protrusive mandible, and a long lower facial height

Årtun and Krogstad[6] (1987) evaluated the periodontal status of mandibular incisors following excessive proclination in orthodontic treatment. The results showed that development of bone dehiscence and some gingival retraction during excessive proclination of mandibular incisors seem to be inevitable, especially in patients with thin alveolar housing. However, the long-term prognosis for such teeth with extensive gingival recessions may not be critical.

Most of the retraction seems to take place during or shortly after active appliance therapy. Once the bone dehiscence is eliminated through retraction of the gingiva until a normal distance is established between level of connective tissue attachment and crestal bone, further gingival retraction may be inhibited.

Wennstrom[56] (1987) examined the cause and effect relationship between gingival recession and width of attached gingiva. 6 patients were followed over a 5 year period with maintenance visits every 6 months. So, with good oral hygiene practice recession of the “soft tissue margin” or attachment loss is independent of (1) the presence or absence of attached gingiva, (2) width of keratinized gingiva, or (3) the height of the periodontal support. The study demonstrated that lack of or presence of minimal amounts of attached gingiva at the buccal aspects of teeth does not necessarily result in the development of soft tissue recessions. The development of a soft tissue recession at the 3 control sites resulted in a decreased width of the gingival. The study concludes that a narrow zone of gingiva apical to a localized recession is a consequence rather than a cause of the recession.

Boyd R. L., Leggott P. J, Quinn R. S., Eakle W. S, and Chambers D[12] (1989) did a longitudinal study monitoring the periodontal status in 20 adults and 20 adolescents undergoing fixed orthodontic treatment. Ten adults had generalized periodontitis and received periodontal treatment, including periodontal surgery, before orthodontic treatment. They also received periodontal maintenance at 3-month intervals during orthodontic treatment. The other 10 adults had normal periodontal tissues. Neither these latter adults nor the adolescents received periodontal maintenance during orthodontic treatment. The results of this study indicate that during the course of fixed orthodontic treatment: Tooth movement in patients with a reduced but healthy periodontium does not result in significant further loss of attachment. Tooth loss for periodontal reasons may occur in adults with severely periodontally compromised teeth that have pocket depths > 6 mm and/or advanced furcation involvements. Adolescents are likely to show significantly more plaque accumulation and gingival inflammation during fixed orthodontic treatment than adults.

Andlin-Sobocki A[5] (**1993)** monitored the changes of the width of keratinized and attached gingiva in children. The anterior mandibular and maxillary gingiva of 96 children, 6-12 yrs were examined twice with an interval of 2 years. Also, study models were used to determine the facial/lingual tooth positioning. During the 2 year observation period in well aligned teeth, increases in the width of the facial keratinized and attached gingiva took place in both primary and permanent teeth. The increase was smallest in those teeth with wider zones at first examination. Typically, changes were greater for deciduous teeth present at both examinations that for permanent teeth present at both examinations. Changes in attached gingiva from a deciduous tooth to permanent successor were variable, but if the deciduous tooth had less than 1 mm of attached gingiva at baseline, the permanent tooth had a wider zone of attached gingiva at the 2nd examination. As teeth moved lingually, an increase in the width of the attached and keratinized tissue was evident. They concluded that in children with well-aligned teeth and minimal zone or absence of attached gingiva, a conservative, monitoring approach is recommended prior to a corrective, surgical procedure.

Andlin-Sobocki, Bodin[4] (1993) determined whether the facial and lingual tooth position changes are related to alterations in the width of keratinized gingiva, attached gingiva, and crown heights. There were 38 children between the ages 7 and 12 with teeth in the facial or lingual position that were observed for 2 years. They examined width of keratinized gingiva and attached gingiva. The central incisors, lateral incisors and canines were used. They were placed in six groups. AL- normally aligned that moved lingually, LA- lingual positioned that become aligned, AF- normally aligned that moved facially, LL- lingually positioned that moved more lingual, and FF- facially positioned that moved more facial. There were narrower zones of keratinized gingiva and attached gingiva for teeth in the facial position versus lingual position. For the AL group the width of the keratinized and attached gingiva increased significantly. Teeth in the LA group which had moved facially showed a decrease in the keratinized gingiva. In this group the decrease in the amount of attached gingiva was smaller than the decrease in the keratinized gingiva. Teeth in the AF showed a slight decrease in ginigval widths. The FA group showed an increase in the width of keratinized and attached ginigva. They concluded that when teeth move lingually, the gingival width increased and the clinical crown height decreased and in teeth moving facially, the gingival widths decreased and the facial gingiva sometimes receded.

Handelman[28] (1996) reported that mandibular incisors, more frequently than the maxillary incisors, are the cause of limitation in treatment because of the thinness of their alveolar housing. A narrow alveolus was frequently noted around the mandibular incisors in high MP angled groups and in the class III average groups. While iatrogenic response to challenging the anatomic limits is variable, the severity of this response can compromise the periodontal support of the incisors involved. Patient with either narrow alveolar width or severe skeletal discrepancies are most likely to demonstrate limitation in orthodontic correction and may require surgery. These patients are also likely to exhibit severe iatrogenic loss of periodontal support when tooth movement challenges the orthodontic walls represented by the dense cortical plates at the level of the incisor apices.

Okada N, Kasai K[46] (1996) studied the relationship between mandibular tooth inclination and maxillofacial morphology using CT scanning. They concluded that among the variables of the maxillofacial structure, the mandibular plane angle affected the buccolingual inclination of the mandibular incisors and second molars.

Moriarty[44], (1996) stated that people that have a thin facial to lingual dimension of the alveolus are predisposed to gingival recession. Pseudorecession often occurs in cases of ectopic eruption where the tooth is ectopically positioned relative to the alveolar bone or where a tooth is tipped when the incisal edge is facially proclined. There is much controversy in the literature regarding the amount of keratinized gingiva that is needed to prevent recession. Precipitating factors to recession include plaque derived inflammation, toothbrush trauma, and direct trauma or laceration.

Prior to orthodontic treatment the potential for recession, anatomic and traumatic factors, should be assessed. If orthodontic therapy will improve the position of the tooth within the bony housing then the potential for recession is reduced. If the facial to lingual dimension of the tooth is thin and the tooth is moved out of the bony housing by bodily movement or tipping prophylactic gingival grafting should be considered. However the clinical evaluations and assessments are all subjective. Objective measures such as measurement of the width of keratinized gingiva are inadequate predictors of recession when evaluated alone. Assessments must include anatomy, relative trauma to the area and potential for positive or negative influences on orthodontic movement.

Wennstrom[57], (1996) stated that localized gingival recessions are often found at malaligned teeth that have a buccally deviated position of the root with an accompanying alveolar bone dehiscence. Such predisposing alveolar bone dehiscences may also be induced by orthodontic tooth movement.

Muller HP, Eger T[45] (1996) studied on 42 young adult, periodontally healthy subjects without any attrition, abrasion or crown restoration to identify subjects with different morphological characteristics of gingiva, i.e., gingival phenotypes by a novel ultrasonic device. When employing cluster analysis on standardized parameters mean Gingival Thickness (GTH), Width of attached gingiva (WG) and crown width/crown length (CW/CL) of upper canines, lateral and central incisors, 3 clusters were identified. Cluster A comprised 2/3 of subjects, displaying "normal" GTH, WG and CW/CL. Cluster B (n = 9, 21%) had a significantly thicker and wider gingiva, and a more quadratic form of upper front teeth. A 3rd cluster (cluster C, n = 5, 12%) was identified showing "normal" GTH, high CW/CL, but a narrow zone of keratinized tissue. Present results clearly indicate evidence for the existence of different gingival phenotypes.

Ashley F P, Usiskin L A, Wilson R F and Wagaiyu E[7] (1998) investigated the relationship between irregularity of teeth and periodontal disease in 201 children aged 11–14 years. The upper and lower incisor teeth were assessed for spacing, labio-lingual displacement, and mesiodistal overlap. Plaque and gingivitis were assessed at six sites on each of the four upper and four lower incisor teeth. The pattern of correlation observed between irregularity and gingivitis indicated a consistent, statistically significant, direct relationship between the number of sites with labio-lingual displacement combined with mesiodistal overlap and gingivitis.

Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, Tuinzing DB[8], (1998) investigated the relationships between the lower face height and the structure of the frontal alveolar and basal bone. The areas and the dimensions of the anterior alveolar and basal midsagittal cross-sectional bone from the maxilla and the mandible were recorded on lateral cephalograms from 460 untreated adults. A larger lower face height coincided with a larger maxillary alveolar and basal area and with a smaller mandibular alveolar index. Correlations between the lower face height and the maxillary alveolar index and the mandibular alveolar and basal area were low. It is concluded that long-faced subjects have a large mandibular alveolar height, which is more associated with a narrowed shape than with a large volume of the symphysis.

Tsunori M, Mashita M, Kasai K[54] (1998) evaluated the relationship between morphological characterictics of vertical sections of the mandibular body and facial type. The results showed that the buccal cortical bone was thicker in the short faced individuals than the long faced and average faced groups.

Ishikawa, Nakamura, Iwasaki, Kitazawa, Tsukada, Sato[32] (1999) investigated dento-alveolar compensation for various sagittal jaw relations in

44 adult female patients with normal incisor relation and either skeletal class I or skeletal class III relationships. They found that the most appropriate cephalometric parameter describing dento-alveolar compensation quantitatively is SN-AB as a skeletal measurement. And among the compensatory dento-alveolar changes the lower incisor inclination was strongly related to the sagittal jaw relation and played an important role in obtaining a normal incisor relationship.

Ishikawa, Nakamura, Iwasaki, Kitazawa, Tsukada, Chu[33] (2000) examined negative overjet cases with either skeletal Class I or skeletal Class III jaw relationships, and evaluated their dental compensation in relation to sagittal jaw relationships by using the 4 cephalometric parameters. These correlations confirmed dentoalveolar compensatory changes in the negative overjet cases: as the sagittal jaw relationship worsens, the maxillary incisors incline more labially, the mandibular incisors more lingually. The results appear to confirm the suggestion by several authors that malocclusion results from insufficient dentoalveolar compensation for variations in the sagittal jaw relationships, though there must be limits in sagittal jaw relationships where normal incisor relationships are obtained. Therefore, the mandibular incisor inclination in negative overjet cases is considered to be strongly regulated by the sagittal jaw relationship.

Djeu G, Hayes C, Zawaideh S[18] (2002) studied to determine whether proclination of mandibular central incisors during fixed appliance therapy results in gingival recession. Complete records of 67 patients (39 female and

28 male patients; mean age, 16.4 years; age range, 10–45 years) were used in this retrospective casecontrol study. Using pretreatment and posttreatment lateral cephalograms, the change in mandibular central incisor inclination was measured to divide the patients into an experimental group (proclination) and a control group (no proclination). Statistical analyses showed no correlation between mandibular central incisor proclination and gingival recession or clinical crown length. A *t*-test analysis showed no statistically significant difference in gingival recession or change in clinical crown length between patients whose mandibular central incisors were proclined and those whose incisors were not proclined. Multiple regression analysis demonstrated that age, sex, race, treatment duration, extraction, treatment type, Angle classification, and proclination were not related to gingival recession or change in clinical crown length of mandibular central incisors. We conclude that the degree of proclination of mandibular central incisors during fixed appliance therapy was not correlated to gingival recession in this sample.

Allais D and Melsen B[2] (2003) evaluated the association between the extent of labial movement of the lower incisors and the prevalence and severity of gingival recession in orthodontically treated adult patients. It was a retrospective case–control study based on the analysis of study-casts and intra-oral slides of 300 adult patients was carried out. One hundred and fifty pairs matched by age and sex were selected using simple random sampling. Recordings of gingival recession were made using casts as well as intra-oral slides. Dental displacement was measured on casts comparing the measurements before and after treatment. This study demonstrated a significant increase in the prevalence of individuals exhibiting dehiscence. They also found that new recessions developed in 10 per cent of the investigated teeth but improved in 5 per cent. They concluded that controlled proclination under maintenance of good oral hygiene can be carried out in most patients without risk to the periodontium.

Melsen and Allais[42] (2005) assessed changes in prevalence and severity of gingival recession of mandibular incisors during orthodontic treatment of adults in whom the incisors had been moved labially and to identify parameters that could predict recession. The results showed that orthodontic treatment did not increase gingival recession significantly. Only 15% of the teeth experienced development or aggravation of recession, and local factors related to anatomy and periodontal health could be applied to identify patients at risk. They also stressed on the impact of the width of keratinized gingiva and of gingival biotype making it advisable to perform mucogingival surgery before orthodontic treatment in at-risk patients.

Savitha, Vandana[49] (2005) assessed the gingival thickness in relation to central incisor lateral incisor in Indian population. The gingival thickness was assessed in patients with healthy gingiva, mid-buccally in the attached gingiva, half way between mucogingival junction and free gingival groove. The mean gingival thickness midbuccally at 338 sites determined by Transgingival probing measurements was 1.08 f 0.42 with measurements ranging from 0.5 to 2.5 mm

Holmes, Tennant, and Goonewardene[30] (2005) studied to determine in an animal model whether any increase in gingival thickness after placement of free connective tissue autografts is maintained after labial orthodontic tooth movement. The following conclusions were drawn: Free connective tissue grafts (FCTG) placed on the labial aspect of maxillary incisors produce a small but significant increase in gingival thickness up to 8 months after surgery. Thinning of labial gingival tissues during orthodontic tooth movement can be reduced by the placement of FCTGs on the labial aspect of incisors before labial orthodontic tooth movement. When indicated, free connective tissue grafting is a suitable method for augmenting gingival tissues.

Yared KF, Zenobio EG , Pacheco W[61] (2006) assessed the periodontal status of mandibular central incisors that were proclined during orthodontic treatment. The results showed no correlation between recession and the plaque and gingival bleeding indexes, probing pocket depth, and total quantity of labial movement ($P > .05$). Recession was negatively correlated with keratinized gingival height and thickness of the facial gingival margin on the mandibular central incisors. Final inclination (>95 degrees) and free gingival-margin thickness (>0.5 mm) showed greater and more severe recession on the mandibular central incisors. In conclusion, when comparing thickness to the final inclination, thickness had greater relevance to recession.

Closs LQ, Branco P, Rizzatto SD, Raveli DB, Rösing CK[15] (2007) associated the amount of keratinized gingiva present in adolescents prior to orthodontic treatment to the development of gingival recessions after the end of treatment. The sample consisted of the intra-oral photographs and orthodontic study models from 209 Caucasian patients with a mean age of 11.20 ± 1.83 years on their initial records and 14.7 ± 1.8 years on their final records. The results showed that the teeth that developed gingival recession and those that did not have their gingival margin position changed did not differ in relation to the initial amount of keratinized gingiva. They concluded that the mean amount of keratinized gingiva did not predispose lower incisors and canines to gingival recession.

Krishnan, Ambili R, Davidovitch Z, and Murphy NC[37] (2007) attempted to provide current information regarding clinical, microscopic, and molecular level effects of orthodontic tooth movement on gingival tissues during fixed appliance therapy, or remedial methods once orthodontic appliances are removed. They concluded that preorthodontic gingival augmentation procedures are indicated in patients with thin gingival tissue and in areas of possible arch expansion, but not if tooth movement is constrained to the envelope of the alveolar process. The primary therapeutic goal is to increase the buccolingual thickness of the marginal tissues over teeth that might develop alveolar bone dehiscence during tooth movement. The rationale behind this procedure is that increasing the gingival thickness creates more robust marginal tissues, which are less susceptible to trauma or plaque related inflammation and subsequent re cession. The subepithelial free connective tissue grafting for increasing the apicocoronal width of keratinized gingiva and establishing root coverage in areas of marginal tissue recession is the most preferred method.

Erkan, Pikdoken, and Usumez[21] (2007) investigated the accompanying gingival movement after orthodontic intrusion of periodontally healthy mandibular incisors and to assess the possible effects of orthodontic intrusion on the width of the attached and the keratinized gingivae. The results showed that the gingival margin and mucogingival junction moved in the same direction along with teeth by 79% and 62% of the actual vertical movement, respectively, after orthodontic intrusion of the mandibular central incisors. These results suggest that orthodontic intrusion does not lead to significant changes in the width of attached and keratinized gingivae when adequate plaque control is maintained. The gingiva moves in the same direction with the tooth, yet considerably less. This might indicate the need for follow-up or gingival correction after intrusion therapy.

Yamada C, Kitai N, Kakimoto N, Murakami S, Furukawa S, Takada K [60] (2007) examined if there was any correlation between the labio-lingual inclinations of the mandibular central incisor and the associated alveolar bone, and to investigate the labio-lingual position of the mandibular central incisor root apex in the associated cancellous bone in adults with untreated mandibular prognathism. And they concluded that in adults with mandibular prognathism, when the mandibular central incisor is more lingually inclined, the associated alveolar bone would also be more lingually inclined. The associated cancellous bone was thinner when the mandibular central incisor was lingually inclined. The mandibular central incisor root apex was closer to the inner contour of the labial cortical bone than to the lingual cortical bone. The morphology of the alveolar bone in the central incisor region may be associated with the inclination of the central incisor.

Chung, Jung, Baik[14] (2008) focused on the morphological characteristics of the symphyseal region in adult skeletal Class III malocclusion with crossbite or openbite and compared them with normal occlusion. The results showed that the width of the symphyseal region is similar in adult Class III crossbite and normal occlusion groups, but significantly lower in the adult Class III openbite group. The alveolar height is similar in the adult Class III crossbite and control groups, but significantly lower in the adult Class III openbite group.

Al-Zo'ubiIA, HammadMM, AlhaijaES.JA[3] (2008) studied the relationship between periodontal parameters and vertical facial morphology. Comparing the anatomical measurements of gingival tissues (width of keratinized gingiva, width of attached gingiva, and gingival thickness), between subjects with different facial heights, there were no differences seen among the groups.

Yu Q, Pan X, Ji G, Shen Gang[62] (2009) investigated the relationship between the positioning of the lower central incisor and physical morphology of the surrounding alveolar bone. Thirty-eight patients (18 males, 20 females), with mean age of 13.4 years, were included in this study. As part of orthodontic treatment planning the patients were required to take dental Cone-beam CT (CBCT) covering the region of lower incisors, the sur- rounding alveolar bone and the mandibular symphysis. The cephalometric parameters were designed and measured to indicate the inclination of lower central incisor and physical morphology of the adjacent alveolar bone. Computer-aided descriptive statistical analysis was per- formed using SPSS 15.0 software package for Windows. A correlation analysis and a linear regression analysis between the incisor inclination and the alveolar bone morphology were performed. They concluded that the morphology of the alveolar bone may be affected by incisal inclination.

Jacob S, Zade RM[34] (2009) aimed to assess the width of attached gingiva in the population attending the dental college in Chhattisgarh, India. The distance from the crest of marginal gingiva to mucogingival junction is measured and is subtracted with the probing depth in the mid buccal region to get the width of attached gingiva on the buccal side of all the central incisors, premolars and molars. Mandibular incisors had a width of 2.52mm, and the mandibular molars had the least width of 2.48 mm. There was no relationship with age while females had a greater width of attached gingiva.

Richman C[48] (2010) examined the relationship between GR and the associated tooth position plus tooth volume in the buccolingual dimension, as observed by cone-beam computed tomography (CBCT). Preliminary data from this author's ongoing unpublished office-based studies suggest that more than 75% of patients who have received bicuspid tooth extractions with associated orthodontic therapy demonstrate clinically significant GR at one or more tooth sites. The sagittal plane discrepancy is likely associated with a deficient quantity of facial alveolar bone and thus increased risk for short- or long-term GR. If surgical intervention is considered necessary to reduce the risk of soft-tissue recessions, the goal should be increasing the thickness of the covering tissues (eg, grafts) and not the apico-coronal width of the gingival tissues.

Gracco A, Luca L, Bongiorno MC, Siciliani G[27] (2010) verified the correlation between the morphology of the mandibular symphysis and the various facial typologies used computed volumetric tomography. They concluded that total thickness of the symphysis is greater in short-face subjects than in their longface counterparts. The vestibular portion of the cancellous bone thickness of the symphysis is greater at the central incisors in short-face subjects compared with long-face subjects

Evangelista K, Vasconcelos KF, Bumann A, Hirsch E, Nitka M, Silva M.A.G[22] (2010) compared the presence of alveolar defects (dehiscence and fenestration) in patients with Class I and Class II Division 1 malocclusions and different facial types. They concluded that alveolar defects are a common finding before orthodontic treatment, especially in Class I patients, but they are not related to the facial types.

Mehta P, Peng LL[41] (2010), outlined the concepts on the significance of the width of attached gingiva around teeth to enable the clinician to decide on the need for gingival augmentation in different clinical scenarios. They concluded that if orthodontic movement is predicted to be within the bony alveolus and the patient canmaintain adequate plaque control, no gingival augmentation is indicated. However, if it is likely that orthodontic tooth movement may cause dehiscence then the thickness of the gingival tissues must be evaluated. Gingival augmentation is indicated prior to orthodontic tooth movement if the tissue is thin to prevent unpredictable attachment loss.

Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong DJ, Wang HL[23] (2010) studied to determine the dimensions of the gingiva and underlying alveolar bone in the maxillary and mandibular anterior region and to establish their association evaluated clinically and with CBCT scans. The results showed that the thickness of the labial gingiva had a moderate association with the underlying bone.

Yagci A, Veli I, Uysal T, Ucar Fi, Ozer T, Enhos S[59] (2011) tested the null hypothesis that the presence of dehiscence and fenestration was not different among patients with skeletal Class I, II, and III malocclusions. And they concluded that fenestrations had greater prevalence in the maxilla, a greater number of dehiscences were found in the mandible for all groups. Alveolar defects were predominant in the buccal root surfaces. Most fenestrations in the maxilla were seen at the first premolars and the first molars in all investigated groups. However, dehiscences were seen with greater frequency in the mandibular incisors.

Materials & Methods

The present investigation was undertaken to assess the average values of width and thickness of attached gingiva in the labial part of lower incisors in skeletal class I, class II and class III malocclusion in Dravidian population and to determine its relationship with other cephalometric parameters such as lower incisor inclination (IMPA) and vertical skeletal growth pattern (FMA). The study involved a total of 150 subjects attending the dental OP for various reasons other than pain & swelling. The subjects were divided into 3 groups comprising of 50 subjects each depending on the nature of the Skeletal pattern.

THE EXCLUSION CRITERIA FOR THE STUDY WERE

1. Patients who had undergone previous orthodontic treatment or those undergoing treatment.
2. Periodontally compromised patients or those who had undergone comprehensive periodontal treatment.
3. Medically compromised patients.
4. Patients undergoing medication for systemic disease.
5. Patients with missing teeth other than third molars.
6. Patients with mobile teeth in the lower anterior region.
7. Patients with poor oral hygiene.

Informed consent was obtained from all patients participating in the study and the study protocol was reviewed by the Institutional Review Board of Ragas Dental College & Hospital, Chennai.

Case history was taken for every patient involving personal history, medical and dental history, habits and clinical examination of both extra-oral and intra-oral tissues were recorded.

Methodology

Lateral cephalagrams were taken using KODAK Medical X-ray film of size 20.3 x 25.4 cm (8 x 10inches). All the cephalograms were traced manually & the landmarks identified by the same examiner. All Cephalograms were taken in natural head position with the Frankfort Horizontal plane parallel to the floor.(fig 1)

Cephalometric criteria.

The following points and planes were located on the radiographs: sella, nasion, points A and B, gonion, menton, S-N Plane and Mandibular plane[40].(fig 2)

The cephalometric parameters used in this study were

1) ANB to assess the skelatal pattern in the anterio posterior dimension

2) FMA to assess the skeletal pattern in the vertical dimension.

3) IMPA to assess the mandibular incisor inclination[17]

All the patients were classified according to skeletal pattern in to 3 groups as;

Class I - Skeletal Class I malocclusion. ANB (0º - +4º)

Class II - Skeletal Class II malocclusion. ANB (> +4º),

Class III - Skeletal Class III malocclusion. ANB (< 0º),

Since the incisors were being studied, the ANB difference was used for the skeletal classification according to ***Holdaway***[29]. Thus skeletal class I had an ANB difference in the range of 0º - +4º, class II had an ANB difference in the range of > +4º, and class III had a range < 0º[5].

The selected 150 samples were futher divided into into two sub groups:-

(a) Based upon the work of earlier investigators, ***Downs W.B (1948), Steiner C.C (1953), Tweed (1954)***[53] the accepted norm for incisor inclination for mandibular incisor was 90º ± 5º. The incisor angulations found in this study population were grouped as;

i) less than 85º

ii) 85º - 95º

iii) more than 95º

(b) Based on FMA, Frankfort – Mandibular Plane angle given by **Charles H.Tweed**[52] **(1946),** is used in this study to define the direction of facial growth in vertical dimension. The normal range for this angle is 22º-28º. Accordingly this is categorized into three groups as ;

i) Below 22º - Low angle group

ii) 22º-28º - Average angle group

iii) Above 28º - High angle group

Gingival parameters

The width of attached gingiva was measured in the four mandibular incisors (32,31,41,42) in the mid - buccal area of the labial gingiva. Correspondingly the thickness of attached gingiva was taken in the centre of the mid - buccal segment of the attached gingiva.

Armamentarium;

(Hufriedy's) William's Probe (with the markings 1,2,3,5,7,8,9 & 10), millimeter scale, 15 size endodontic hand file with a rubber stop, local anesthetic spray. (fig.3 & 4)

The Width of attached gingiva

The Width of attached gingiva was calculated by subtracting the depth of the gingival sulcus from the distance between the free gingival margin and the mucogingival junction. This was measured using a universally standaratized probe – (Hufriedy's) William's Probe. (fig.5 & 6)

The Thickness of attached gingiva.

The Lower anterior region was anesthetized with local anesthetic spray and then the thickness was measured using a 15 size endodontic hand file with a rubber stop in the midbuccal aspect of the lower incisors - 42,41,31 and 32, measured midway between the gingival sulcus depth and mucogingival junction.(fig.7 & 8)

Statistical analysis

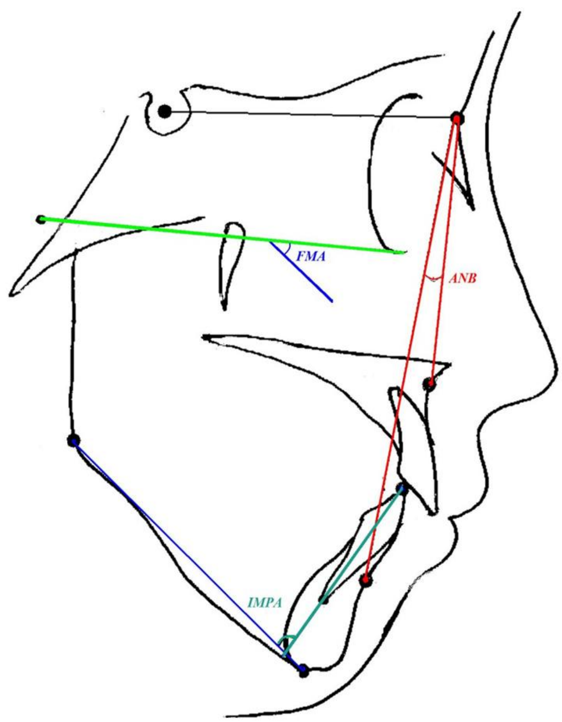
All the statistical analysis was performed SPSS software. One-way ANOVA was used to compare the mean values of width and thickness of attached gingiva between groups. The Tukey HSD post hoc test is a single-step multiple comparison procedure and a statistical test generally used in conjunction with an ANOVA to find which means are significantly different from one another. The correlation between the different parameters assessed in relation to the width and thickness of the attached gingiva of the lower labial gingiva were done by Pearson's correlation coefficient 'r'.

Method error

The reliability of the measurements was assessed by reexamining and remeasuring records for 10 subjects with an interval of 1 week. Kappa statistics were used to evaluate the errors in categorical data. Results of the kappa values were above 80%, which indicates substantial agreement between readings.

Fig.1 : Cephalostat with patient positioned in Natural Head Position

Fig.2 : Cephalometric tracing showing angles ANB, IMPA & FMA



Armamentarium

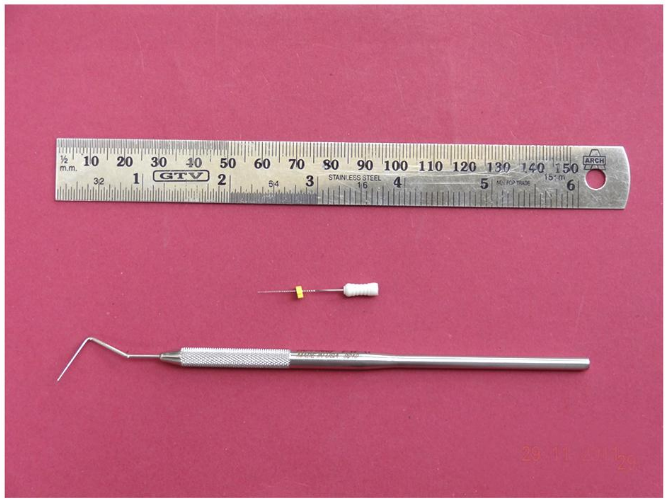
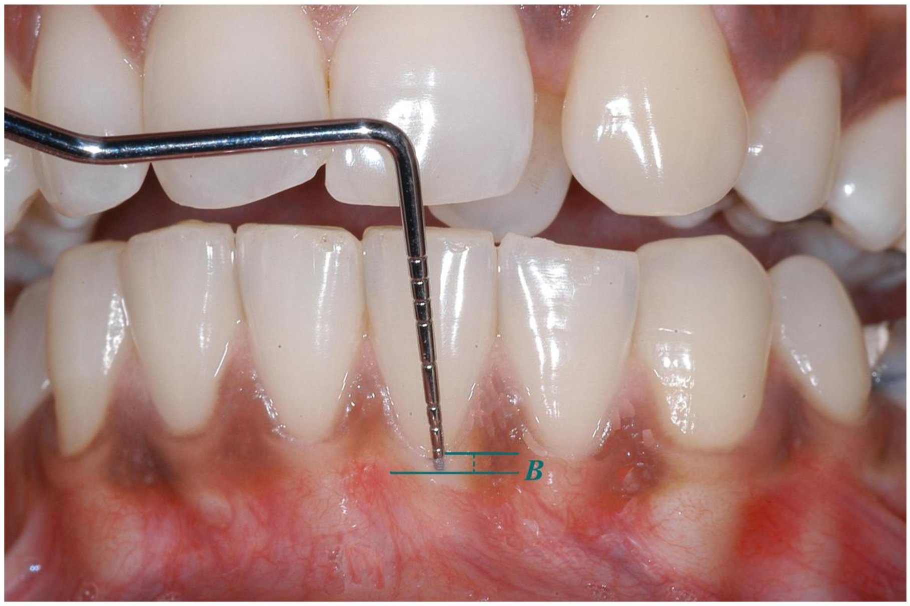
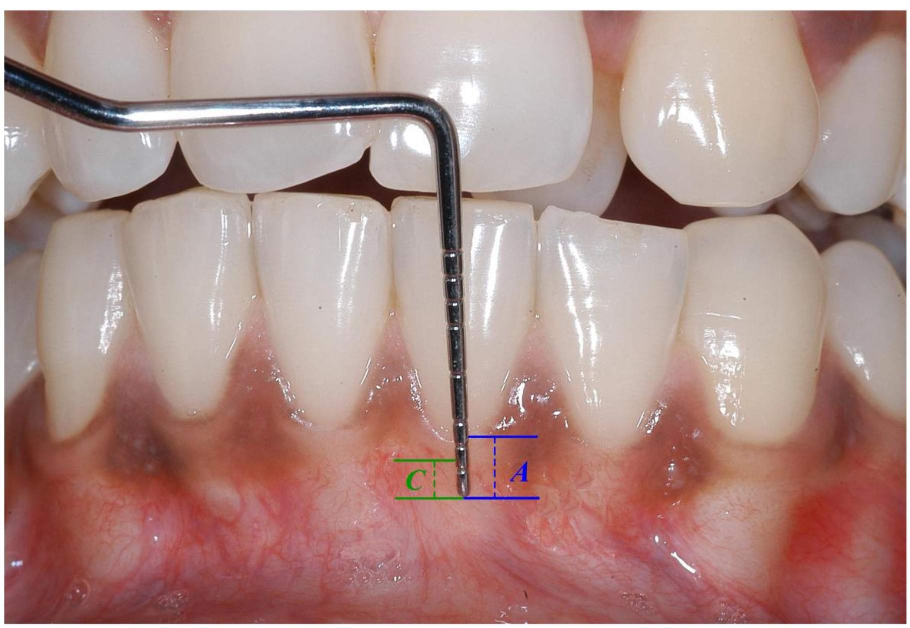


Fig.3 : (Hufriedy's) William's Probe, millimeter scale, 15 size endodontic hand file with a rubber stop

Fig.4 : (Hufriedy's) William's probe (with markings 1,2,3,5,7,8,9 & 10)

Fig5 & 6: Width of attached gingiva from the base of the gingival sulcus to the mucogingival junction



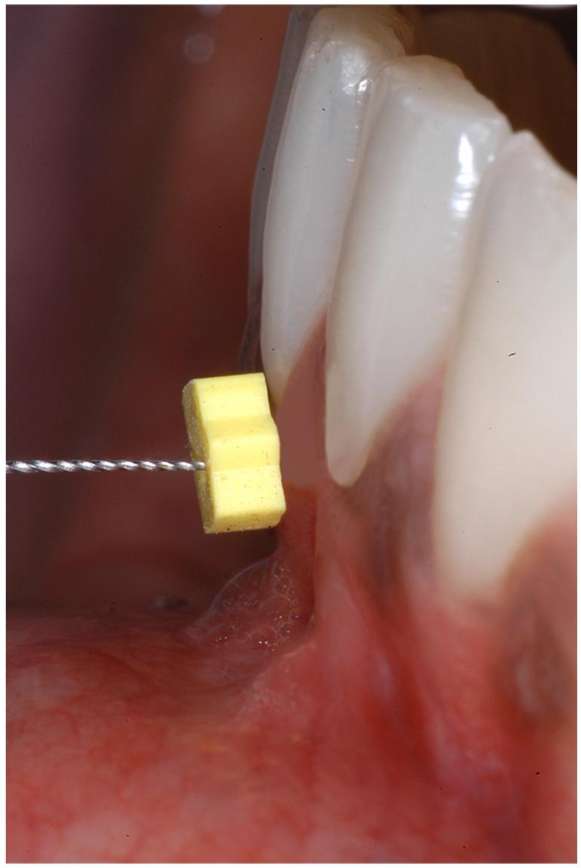


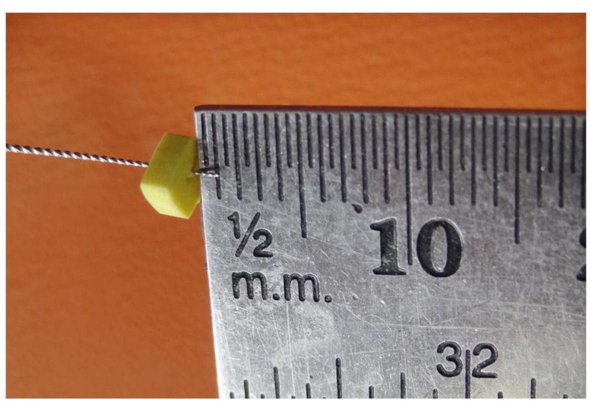
A = Distance from gingival margin to mucogingival junction :

B = Gingival sulcus depth

C = (A - B) Width of attached gingiva

Fig 7 & 8 : Measurement of thickness of attached gingiva

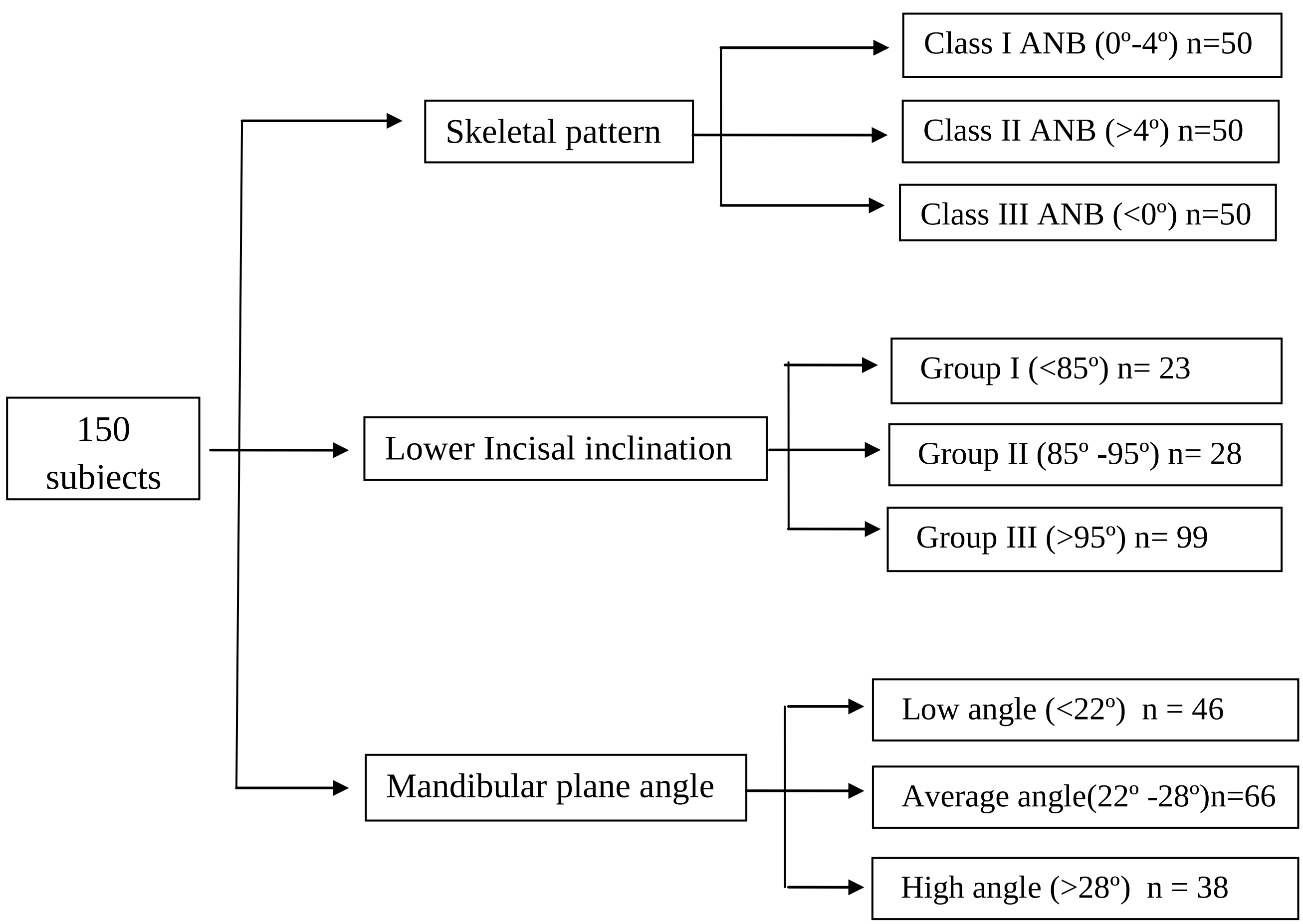




Results

The study consisted of 150 subjects of Dravidian origin (85) male and (65) female patients with a mean age of 21.7+/-3.0yrs. All the subjects were classified in three ways as shown in flowchart below;

1. According to skeletal pattern
2. According to lower incisal inclination
3. According to mandibular plane angle



One way ANOVA was used to compare the mean values of a) width of attached gingiva, b) thickness of attached gingiva in each of the three skeletal malocclusions, the three IMPA groupings and the three mandibular plane angle groups.

Tukey HSD Post Hoc tests were used for multiple pair wise comparisons within the groups for each variable.

1. ***Assessment of width of attached gingiva***

   a) In relation to skeletal pattern

The mean width of attached gingiva seen in skeletal class I (ANB 0º-4º) was 1.17± 0.3 mm, in skeletal class II (ANB >4º) was 1.40± 0.4mm and in skeletal class III (ANB <0º) was 1.14± 0.3mm and the difference between them was statistically significant with a P-value of 0.004(Table 1a)(Chart 1)

On comparing the mean width of attached gingiva between skeletal class I and skeletal class II the mean difference was 0.225mm with a statistical significance of 0.019, similarly between skeletal class II and skeletal class III the mean difference was 0.254mm with a statistical significance of 0.007, whereas the mean difference between skeletal class I and skeletal class III was 0.029mm with no statistical significance (Table 1b).

b) In relation to mandibular incisal inclination (IMPA)

The mean width of attached gingiva seen in group I IMPA (<85º) was 0.90 ± 0.2mm, group II IMPA (85º -95º) was 1.17 ± 0.3mm, and group III IMPA (>95º) was 1.32 ± 0.4mm. and the difference between them were statistical significant with a P-value of <0.001 (Table 2a)(Chart 2)

On comparing the mean width of attached gingiva between group I IMPA and group II IMPA the mean difference was -0.275mm with a statistical significance of 0.04, likewise between group I IMPA and group III IMPA the mean difference was -0.428mm with a statistical significance of <0.001, whereas the mean difference between group II IMPA and group III IMPA was -0.153mm with no statistical significance (Table 2b).

c) In relation to Frankfort – mandibular plane angle (FMA)

The mean width of attached gingiva seen in low angle (<22º) group was 1.27 ± 0.3mm, in average angle (22º-28º) group was 1.22 ± 0.3mm and in high angle (>28º) group was 1.13 ± 0.4mm and the differences between was not statistically significant with a P-value of 0.241 (>0.05)(Table 3a)(Chart 3).

On comparing the mean width of attached gingiva between the three groups, low angle group, average angle group and high angle group the mean differences between them didn't show any statistical significance (Table 3b).

2. Assessment of thickness of attached gingiva

a) In relation to skeletal pattern

The mean thickness of attached gingiva seen in skeletal class I (ANB 0º-4º) was 1.10 ± 0.3mm, in skeletal class II (ANB >4º) was 1.19 ± 0.4mm and in skeletal class III (ANB <0º) was 0.88 ± 0.3mm and the difference between them were statistically significant with a P-value of <0.001 (Table 4a)(Chart 4)

On comparing the mean thickness of attached gingiva between skeletal class I (ANB 0º-4º) and skeletal class III the mean difference was 0.221mm with a statistical significance of 0.014, correspondingly between skeletal class II and skeletal class III the mean difference was 0.309mm with a statistical significance of <0.001, whereas the mean difference between skeletal class I and skeletal class II was -0.088mm with no statistical significance (Table 4b).

b) In relation to mandibular incisal inclination (IMPA)

The mean thickness of attached gingiva seen in group I IMPA (<85º) was 0.74 ± 0.4mm, group II IMPA (85º -95º) was 1.0 ± 0.2mm, and group III IMPA (>95º) was 1.13 ± 0.4mm and the difference between them was statistically significant with a P-value of <0.001 (Table 5a)(Chart 5)

On comparing the mean thickness of attached gingiva between group I IMPA and group III IMPA the mean difference was -0.391mm with a statistical significance of <0.001. Comparisons of group II IMPA with group I IMPA and group III IMPA, showed mean differences of -0.252mm and -0.139mm with no statistical significance (P>0.05)(Table 5b)

c) In relation to Frankfort – mandibular plane angle

The mean thickness of attached gingiva seen in low angle (<22º) group was 1.12 ± 0.3mm, in average angle (22º-28º) group was 1.03 ± 0.3mm and in high angle (>28º) group was 1.03 ± 0.5mm and the differences between them was not statistically significant, since P-value was >0.05 (Table 6a)(Chart 6).

On comparing the mean thickness of attached gingiva between the three groups, low angle group, average angle group and high angle group the mean differences between them didn't show any statistical significance (P>0.05) (Table 6b).

Pearson correlation coefficient

The Pearson correlation coefficient is used here to correlate the gingival parameters width and thickness of attached gingiva with 1) the type of skeletal pattern, 2) the lower incisor angulation (IMPA) and 3) the Frankfurt-Mandibular plane Angle (FMA).

Guidelines on strength of relationship

Value of r	Strength of relationship
-1 –0.6 or 1-0.6	Strong
-0.6 – -0.3 or 0.3 –0.6	Moderate
-0.3 – -0.1 or 0.3 – 0.1	Weak
-0.1 – 0.1	None or very weak

1. *Correlations between skeletal pattern and width & thickness of attached gingiva*

When each skeletal pattern was correlated with width and thickness of attached gingiva, skeletal class I (ANB 0º - 4º) was moderately and negatively correlated with thickness of attached gingiva (r= -0.535) with statistical significance ($P<0.001$) and weakly correlated with width of attached gingiva (r= 0.135) with no statistical significance.

Skeletal class III (ANB <0º) was moderately correlated with width of attached gingiva (r= 0.352) with a statistical significance of (0.012) and weakly correlated with thickness of attached gingiva (r= 0.297) with statistical significance of (0.036).

There was no statistical significance in the correlations between skeletal class II (ANB >4º) and width and thickness of attached gingiva. (Table 7)(Chart 7).

2. *Correlations between IMPA and attached gingiva*

When correlations were made between IMPA divided into 3 groups and the width and thickness of attached gingiva, the correlation between group I IMPA (<85º) and width and thickness of attached gingiva showed moderate strength (r= 0.597), (r= 0.391) and statistical significance of (0.003), (0.007) respectively.

The Group II (85º - 95º) IMPA was strongly correlated with the width of attached gingiva (r= 0.669) with statistical significance ($P<0.001$) and weakly correlated with thickness of attached gingiva with no statistical significance.

The Group III (>95º) was weakly correlated with both width and thickness of attached gingiva with no statistical significance (Table 8)(Chart 8).

3. *Correlations between FMA and attached gingiva*

When correlations were made between the three groups of mandibular plane angle and width and thickness of attached gingiva, the low angle group (<22º) was moderately correlated with thickness of attached gingiva with a statistical significance of (0.019).

The average angle group (22º-28º) and high angle group were weakly correlated with width and thickness of attached gingiva with no statistical significance.

The high angle group (>28º) showed a negative correlation with thickness of attached gingiva but the strength (-0.262) was weak (Table 9)(Chart 9).

4. *Comparison between skeletal pattern, IMPA and FMA in relation to the width and thickness of attached gingiva*

No statistical significance is seen between skeletal pattern, IMPA and FMA in relation to the width and thickness of attached gingiva, since P-value was >0.05..

In relation to width of attached gingiva, the strength of correlation was weak with all the three variables, values descending in the order of IMPA (r= 0.273), skeletal pattern (r= 0.257) and then FMA (r= 0.255).

Pertaining to thickness of attached gingiva, IMPA and the skeletal pattern were moderately correlated with a strength of (r= 0.324), (r= 0.316) respectively and the FMA weakly correlated with a strength of (r= 0.289).

Among the three variables, IMPA showed a greater correlation value in relation to both width and thickness of attached gingiva (Table 10).

Discussion

It is widely believed that an important rationale for performing orthodontic treatment is to promote the health of the periodontium, by placing the teeth in position which will be conducive for good plaque control and maintenance of the periodontal health[12].

The relationship between malocclusion and periodontal disease has received much atten tion in the literature, with little support for such a relationship.[7] ***Wennstrom (1996)*** [57] stated that localized gingival recessions are often found at malaligned teeth that have a buccally deviated position of the root with an accompanying alveolar bone dehiscence.

It has been argued that orthodontic treatment may have some adverse effects on the gingival and periodontal tissues which may hasten or promote periodontal breakdown in later life[16]. ***Sperry et al (1977)*** [51] documented that, as the mandibular incisors retroclined, their roots gained labial prominence, and some camouflaged incisors exhibited gingival recession. Most of the studies on the effects of orthodontic treatment on periodontal health have been concerned with the effects during treatment and up to a few years after treatment, with no long-term follow up.[63,64]

. ***Kloehn (1974)*** [36] reported significantly more mucogingival problems (42.5%) in a group of forty orthodontically treated subjects at least 5 years after treatment as compared to a control group with relatively normal occlusions (12.5 %). ***Dorfman (1978)*** [19] studied the mucogingival changes resulting from mandibular incisor tooth movements in 1,150 completed orthodontic cases. He found that a small percentage of cases (1.3 percent) showed a decrease in width of keratinized gingiva. These were statistically correlated with the magnitude and direction of tooth movement.

Significance of attached gingiva

In the early ***1980s, Wennstrom et al*** [55] conducted a series of well designed experiments to prove that the attached gingiva and its width, have little role in maintaining periodontal health[10]. Successive studies by, ***Maynard and Oschsenbein (1975)*** [39]***, Miyasato et al (1977)*** [43] went on to prove that it is not the width but the volume of attached gingiva that is critical around restored or orthodontically moved teeth.' Towards the end of the 1980s, the controversy around the significance of the width of attached gingiva had been resolved and clinicians were presented with clear guidelines to evaluate the width of attached gingiva and indications for gingival augmentation procedures.[11]

A buccally positioned tooth may show alveolar dehiscence with a thin gingiva.[27] Lingual movement of the tooth as part of overall orthodontic management of the patient will increase the thickness of labial gingival tissue and decrease the buccal recession as the tooth adopts a more favourable position within the alveolar bone. As long as the tooth is moved within the alveolar bone, a risk of recession during orthodontic tooth movement is minimal. If the tooth movement is likely to lead to creation of alveolar dehiscence, then the volume of covering soft tissue should be reviewed.[58] The presence of thin gingiva in such situations may be a risk factor for recession and increasing the volume of the soft tissue by grafting before commencing orthodontic tooth movement is considered.[42] Tooth movements such as proclination of lower incisors and arch expansion are associated with a greater risk of gingival recession than other orthodontic interventions.[18].

Geiger (1980) [25] in his clinical review about mucogingival problems and movement of mandibular incisors concluded that orthodontic movement of abnormally positioned teeth or those subjected to trauma may contribute significantly to the repair of pathologic recession or prevent loss of attachment in cases with potentially inadequate attached gingiva.

A number of papers have been written on the relationship between malocclusion and periodontal disease.[7,63] The samples used and the methods of evaluation have varied, and results have been conflicting and contradictory.

The lower labial gingival architecture in health is highly dependent on the structure of the alveolar process. The dimensions of the alveolar process can again be variable depending upon the antero-posterior and vertical skeletal pattern.[58] Another important factor which can influence the nature of the alveolar process is the lower incisor axial inclination.

Each of these factors has been studied individually by different authors who have reported clinical significance in relation to the nature of lower labial gingival architecture.[21] However the correlation using all three variables have not been reported in literature in our population.

Therefore, the primary aim of this study was to measure the width and thickness of the attached gingiva of the lower anteriors in skeletal Class I, Class II and Class III malocclusion and to determime a working norm in Dravidian population and find its relationship to the lower incisor inclinations(IMPA) and the vertical skeletal patterns(FMA). A total of 150 patients were divided into 3 groups (skeletal Class I, Class II and Class III) of 50 patients in each group.

Our study involved non-growing individuals between the age 19 – 30 with well established dentition, because dimensional alterations of the attached gingiva occurs during transition period from deciduous to permanent dentition and throughout the development of permanent dentition. To eliminate bias, only patients with good oral hygiene were considered in this study. Plaque index (PI) was measured for all the patients as described by ***Silness and Loe (1964)*** [50]**.** This selection may exclude the well-established effect of poor oral hygiene on periodontal health, which may obscure the main objective of our study. In fact, the records of plaque index and oral hygiene habits showed that all groups had comparable good oral hygiene level and low plaque index scores.

Assessment was done only on the labial aspect of the lower incisors since orthodontic tooth movement most commonly affected the gingival parameters in this part of the dentition (***Dorfman 1978*** [19]***).*** Lower incisal axial inclination had no effect on lingual recession as categorically reported by ***Geiger and Wasserman (1976)*** [24]**.** Furthermore, lingually the marginal gingiva tends to continue with the lingual mucosa with no discernible mucogingival line.

Tweed et al., 1954 [54] stated that the mandibular incisors should create an average angle from 85° to 95° with the mandible plane if the mandible plane to the Frankfort plane angle falls in the 22° to 28° range. Any values above and below these average values were grouped in separate groups. Therefore, in this study the mandibular incisor inclinations(IMPA) are grouped accordingly, into Group i) < 85°, Group ii) 85° - 95°,and Group iii) > 95°. Similarly, the mandibular plane angle (FMA) was grouped as; Group i) <22°, Group ii) 22° - 28° and Group iii) > 28°

Results of our study showed –

Assessment of width and thickness of attached gingiva selected from patients of Dravidian origin were-

In relation to skeletal pattern

1) The average width and thickness of the attached gingiva in skeletal class 1 patients in this study population was 1.17± 0.3mm and 1.1 ± 0.3 mm respectively.
2) The average width and thickness of the attached gingiva in skeletal class II patients in this study population was 1.40 ± 0.4mm and 1.19 ± 0.4mm respectively.
3) The average width and thickness of the attached gingiva in skeletal class III patients in this study population was 1.14± 0.3mm and 0.88 ± 0.3 mm respectively.

The average width of attached gingiva found in this study assents with the earlier studies on width of attached gingiva by several authors.[10] ***Lang & Loe (1972)*** [38] showed an average value of 1mm of width of attached gingiva in Caucasian population, similarly ***Jacob and Zade (2009)*** [34] found a mean value of 1.52mm of width of attached gingiva in the mandibular incisors in a periodontally healthy Indian population.

Our results are in agreement with the study done by ***Savitha B and Vandana KL (2005)*** [49]on assessment of gingival thickness, where they have shown average thickness of attached gingiva among the Indian population in the mandibular incisors as 0.97 ± 0.25mm in centrals and 1.08 ± 0.38mm in laterals. Previously, ***Gosalind and Roberson et al (1977)*** [26] showed the average attached gingival thickness in American dental students to be 1.25mm in the mandibular incisal area.

Our study had categorized the subjects into three groups according to 1) the nature of skeletal pattern (ANB), 2) lower incisor inclination (IMPA) and 3) vertical skeletal pattern (FMA) and determined the correlation of the width and thickness of the attached gingiva between the three groups.

1. *Correlation of attached gingiva with the nature of skeletal pattern*

The mean width of attached gingiva was least in skeletal class III (ANB< 0º) with (1.14mm), and in skeletal class I was (1.17mm) and substantially increased in skeletal class II(1.4mm) with a statistical significance of (0.004)(Table 1) (Graph 1). The mean thickness of attached gingiva was least in skeletal class III (ANB< 0º) with (0.88mm) and in skeletal class I was (1.10mm) and substantially increased in skeletal class II (1.19mm) with a statistical significance of (<0.001)(Table 4) (Graph 4)

When correlations were made between the nature of the skeletal pattern and width and thickness of attached gingiva, the results of our study shows that class I skeletal pattern (ANB 0º

-4º), had a negative correlation with moderate strength of (-0.535) with thickness of attached gingiva with statistical significance of <0.001. Similarly, class III skeletal pattern (ANB< 0º) showed moderate correlation of (r - 0.352) with width of attached gingiva and a weak correlation of (r - 0.297) with thickness of attached gingiva (Table 7) (Graph 7).

The difference in values between the study groups have been previously explained in literature and our results adhere with the reported studies.

Yamada et al . (2007) [60] reported that the root apex of the lower central incisors is closer to the internal labial cortex than to the lingual cortex in adult subjects with mandibular prognathism ***Evangelista' (2010)*** [22] and ***Yagci et al . (2011)*** [59] had reported greater prevalence of dehiscence in mandibular incisors with skeletal class III malocclusions.

Studies done by ***Ellis E*** and ***McNamara JA' (1984)*** [20]**,** ***Beckmann et al (1998)*** [8] and ***Chung et al (2008)*** [14] on the components of Class III malocclusions revealed that Class III patients have protrusive maxillary incisors and retrusive mandibular incisors.

The lower incisors are most influenced by the jaw malrelations and tend to compensate the discrepancy by axial inclination, i.e retroclining in class III skeletal pattern thereby causing root prominence in the labial cortical bone and eventual thinning of the alveolus and the overlying gingiva.

2. Correlations of attached gingiva with lower incisor inclination

The mean width of attached gingiva is least in group I IMPA (<85º) with (0.90mm), relatively higher in group II IMPA (85º -95º) with (1.1mm) and increased in group III IMPA (>95º) (1.3mm) with a statistical significance of <0.001 (Table 2) (Graph 2). The mean thickness of attached gingiva is least in group I IMPA (<85º) with (0.74mm), relatively higher in group II IMPA (85º -95º) with (1.0mm) and increased in group III IMPA (>95º) (1.13mm) with a statistical significance of <0.001 (Table 5) (Graph 5).

When correlations were made between IMPA divided into 3 groups and the other variables, statistical significance was seen in the correlation between IMPA and width and thickness of attached gingiva in the group I (<85º) group and the correlation was positive with a moderate strength of (0.597) and (0.391) respectively (Table 8) (Graph 8).

This could be explained by several factors. An earlier study done by ***Geiger and Wasserman (1976)*** [24] reported on the relationship of incisor inclination (cephalometric) to periodontal health to test the hypothesis that “abnormal incisor inclination might be associated with periodontal disease”. The incisor angulations found in this study were grouped as i) less than 85º ii) 85º - 94º iii) 95º - 101º iv) more than 101º. Comparisons of incisor inclination were made with the periodontal destruction found on the labial and lingual surfaces of the incisors. The results showed that labial recession was significantly related to incisor inclination of less than 85º (linguoversion). Progressively less recession was found as the incisor angulation reflected a labial inclination.

The path of eruption and the labiolingual position of teeth may influence the thickness of the gingiva and the alveolar bone. Previous studies done by ***Ainamo and Talari*** **˙** ***(1976)*** **[1]** have indicated that the eruption of the permanent teeth in children is concomitant to a reduction in sulcus depth and the width of attached gingiva

Holdaway (1956) **[29]** discussed a compensatory mechanism which allows a good occlusion to be achieved in a subject with an acceptable facial balance in relation to severe jaw imbalances. ***Bibby (1980)*** **[9]** discussed about the compensatory mechanism attributed by the lower incisor inclination for a large basal bone discrepancy in class III, leading the mandibular incisors to be in a more upright or retroclined position with the labial root prominences resulting in thin buccal cortical plate and correspondingly thinner gingival tissue covering. ***Yu et al (2009)*** **[62]** ,evaluated the relationship between lower incisors and the surrounding alveolar bone and concluded that the morphology of the alveolar bone was affected by lower incisal inclination.

3. Correlations of attached gingiva with Frankfurt mandibular plane angle

The mean width of attached gingiva is least in the high angle group (>28º) with 1.13mm, comparatively higher in average angle group (22º-28º) with 1.22mm and increased in low angle group (<22º) with 1.27mm with no statistical significance. (Table 3). The mean thickness of attached gingiva is least in the high angle group (>28º) with 1.030mm, similar in average angle group (22º-28º) with 1.034mm and increased in low angle group (<22º) with 1.27mm with no statistical significance. (Table 6) (Graph 6)

The correlations between the three groups of mandibular plane angle and width and thickness of attached gingiva, was weak and statistically insignificant (Table 9), which contradicts the study done by ***Handelman (1996)*** [28], who stated that high angle cases presented with thinner labial cortical plate are more prone to gingival recession.

Okada et al (1996) [46] found that among the variables of the maxilla-facial structures in Japanese population, the mandibular plane angle affected the buccolingual inclination of the lower incisors. In a study done by ***Tsunori (1998)*** [54]**,** buccal cortical bone was found more thicker in the short face individuals (low mandibular plane angle) than the long face individuals in the university of Ireland. The inherent population variability may attribute to this difference. Therefore, comparison may not be fair or conclusive.

However, ***Al-Zo'ubi et al. (2008)*** [3]**,** who studied the relationship between the periodontium and vertical facial morphology found that the periodontal health condition in the maxillary and mandibular canines and posterior teeth, represented by clinical attachment level, plaque and gingival index, width of attached gingiva, showed no difference between the different dentofacial vertical patterns.

The present study varies from previous studies- first, regarding the gingival health, our study is the only one to compare these parameters among different skeletal patterns, lower incisor inclinations and vertical growth patterns, while previous studies only discussed bone thickness or density, which may or may not directly affect the health of the periodontium. Secondly, the gingival tissues were not examined in those studies.

4. ***Comparison between skeletal patteren, IMPA and FMA to asses which among these factors have a greater role in determining the width and thickness of the attached gingiva.***

In relation to width of attached gingiva, the strength of correlation was weak with all the three variables, values descending in the order of IMPA (0.273), skeletal pattern (0.257) and then FMA (0.255). Pertaining to thickness of attached gingiva, IMPA and the skeletal pattern were moderately correlated with a strength of (0.324), (0.316) respectively and the FMA poorly correlated with a strength of (0.289) (Table 10) (Graph 10).

Results from our studies indicate that, among the three variables, IMPA showed a greater correlation value in relation to both width and thickness of attached gingiva followed by the nature of the skeletal pattern and and least from the vertical skeletal pattern(FMA). Therefore it can be inferred from the present study, that the gingival parameters cannot be assessed exactly using vertical skeletal pattern. Furthermore, the axial inclination of the lower incisors have shown a greater influence on the gingival parameters rather than the nature of skeletal pattern for this study population.

Biometric studies have described a direct correlation between the presence and extent of alveolar bone dehiscences and the magnitude of associated gingival recession defects ***Fu et al (2010)*** [23]***,*** had shown that the thickness of the labial gingiva had a moderate association with the underlying bone when evaluated with CBCT scans. Thin gingival tissues overlying these dehiscences are very friable and might be prone to recede in response to traumatic insults, such as plaque-related inflammation and traumatic toothbrushing. ***Moriarty and Wennstrom (1996)*** [44, 57] stated that localized gingival recessions are often found at malaligned teeth that have a buccally deviated position of the root with an accompanying alveolar bone dehiscence.'

Orthodontists routinely compare the length of the dental arch perimeter to the mesiodistal dimension of teeth. Thus, space analysis facilitates orthodontic treatment planning, relative to tooth movement in the axial plane. In certain situations, tooth extraction may be necessary, depending on the amount of space needed to functionally and esthetically accommodate all teeth. From the periodontal perspective, however, space analysis does not evaluate the buccolingual (sagittal) dimension of the tooth or associated alveolar bone. This means the various analyses evaluate discrepancies between tooth mass and alveolar bone volume in the axial (horizontal plane) but not in the sagittal (buccolingual) dimension and the associated width and thickness of attached gingiva.

The results of this study clearly indicate that the proper pre-treatment assessment of the periodontal condition is mandatory especially in Class III skeletal pattern and in reduced IMPA angles. Caution should be taken that the IMPA angle be positioned within the alveolar housing following orthodontic treatment as any value less than 85º may negatively affect the labial gingival architecture.

Apart from assessing the width of the attached gingiva, it is also crucial to assess the thickness of attached gingiva in the routine orthodontic diagnosis. The evaluation of gingival tissue biotype is important in orthodontic treatment planning, since thick and thin gingival biotypes are associated with thick and thin osseous patterns, the two tissue types will respond differently to the orthodontic treatment procedures. So, skeletal class III patients and in those patients with reduced IMPA, orthodontic treatment should be done with caution or procedures such as pre-orthodontic gingival augmentation should be undertaken.

The primary therapeutic goal is to increase the bucco-lingual thickness of the marginal tissues over teeth that might develop alveolar bone dehiscence during tooth movement. The rationale behind this procedure is that increasing the gingival thickness creates more robust marginal tissues, which are less susceptible to trauma or plaque related inflammation and subsequent re cession. The subepithelial free connective tissue grafting for increasing the apicocoronal width of keratinized gingiva and establishing root coverage in areas of marginal tissue recession is the most preferred method.[30,37]

Therefore it is crucial for the clinician to critically analyse the nature of the lower gingival tissue architecture and correlate it with other associated factors studied, to bring about optimum treatment results which would be esthetically and functionally stable.

Summary and Conclusion

The primary goal of this study is to analyse the relationship of the nature of skeletal pattern, lower incisor inclination and vertical growth pattern to the gingival parameters (width and thickness of attached gingiva) in the lower labial gingiva. The study comprised of 150 subjects of Dravidian population attending the dental OP. Lateral cephalograms were taken for all the subjects and the cephalometric parameters used in this study were

1) ANB to assess the skaletal pattern in the antero-posterior dimension.
2) FMA to assess the mandibular plane angle for vertical growth direction.
3) IMPA to assess the mandibular incisor inclination.

All the patients were classified in three ways;

a) According to skeletal pattern in to 3 groups as;

Class I - Skeletal Class I malocclusion ANB (0º - +4º).

Class II - Skeletal Class II malocclusion ANB (> +4º).

Class III - Skeletal Class III malocclusion ANB (<0º).

b) According to mandibular incisal inclination;

i) less than 85º

ii) 85º - 95º

iii) more than 95º.

c) According to the FMA, Frankfort – Mandibular Plane angle as ;

i) Below 22º - Low angle group

ii) 22º-28º - Average angle group

iii) Above 28º - High angle group

Assessment of gingival parameters (width & thickness of attached gingiva) in lower incisor region is of profound importance, when undergoing orthodontic therapy especially when the tooth movement is considered in labio-lingual direction. Studies have relied on the nature of skeletal pattern, the axial inclination of lower incisors (IMPA) and the vertical growth pattern (FMA) to validate the amount of bone density which has a profound influence on the gingival parameter.

The result of our study confirms that among the three skeletal patterns, it was the skeletal class III that showed the least width and thickness of attached gingiva (1.14 ±0.3mm) and (0.88 ± 0.33mm) respectively, with a statistical significance of <0.001 between the three groups. However comparing the width and thickness of attached gingiva, the thickness of attached gingiva seem to be having a greater significant correlation between the three skeletal patterns.

When comparing the lower axial inclination (IMPA) to the gingival parameters, it was found that group I (<85º) had the least width and thickness of attached gingiva with (0.90±0.2mm) and (0.74±0.4mm) respectively with a statistical significance of

<0.001. The compensatory mechanism attributed by the lower incisor inclination for a large basal bone discrepancy in class III, leads the mandibular incisors to be in a more upright or retroclined position with the labial root prominences resulting in thin buccal cortical plate and correspondingly thinner gingival tissue covering.

When comparing vertical skeletal pattern, statistical significance was not seen among the three groups of FMA with P-value (>0.05), however it was found that high angle group showed least width and thickness of attached gingiva with an average value of 1.13mm and 1.03mm respectively. The results clearly indicate that gingival parameter in dravidian population show creditable statistically significant difference between the nature of skeletal pattern and the lower incisor inclination, but with no statistical significance in vertical skeletal pattern.

Our study also evaluated, which among the three variables had more significant effect on the gingival parameters. Even though there was no statistical significance between the three variables, it was the lower incisor inclination (IMPA), which seemed to have a greater impact on the width and thickness of attached gingiva, when compared with nature of skeletal pattern and vertical growth pattern.

So, it can be safely concluded that among the studied variables, the width and thickness of the attached gingiva should be periodically monitored in those cases where lower incisor inclination is below 85º and in skeletal class III for a successful orthodontic treatment outcome.

Bibliography

1. **Ainamo J, Talari A**. The increase with age of the width of attached gingiva. J Perio Res 1976;11:182–188.
2. **Allais D and Melsen B** Does labial movement of lower incisors influence the level of the gingival margin? A case–control study of adult orthodontic patients EJO 2003;343-352
3. **Al-Zo'ubiIA, HammadMM, AlhaijaES.JA** Periodontal parameters in different dentofacial vertical patterns Angle Orthodontist, 2008 Nov; 78(6):1006-1014
4. **Andlin-Sobocki A, Bodin L**. Dimensional alterations of the gingiva related to changes of facial/lingual tooth position in permanent anterior teeth of children. A 2-year longitudinal study. J Clin Periodontol 1993;20:219-224.
5. **Andlin-Sobocki A**. Changes of facial gingival dimensions in children. A 2-year longitudinal study. J Clin Periodontol 1993;20:212-218.
6. **Årtun and Krogstad.** Periodontal status of mandibular incisors following excessive proclination AJO-DO 1987 Mar ;225 - 232
7. **Ashley F. P, Usiskin L. A, Wilson R. F and Wagaiyu E**. The relationship between irregularity of the incisor teeth, plaque and gingivitis: a study in a group of schoolchildren aged 11-14 yrs. Eur J Orthod 1998;25:65-72.
8. **Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, Tuinzing DB** Alveolar and skeletal dimensions associated with lower face height AJO-DO1998 May;113:498 - 506
9. **Bibby.R.E**, Inscisor Relationships in Different skeletofacial patterns. Angle Orthodontist 1980 Jan;50(1):41-44.

10. **Bowers GM**. A study of the width of attached gingiva. J Periodontol 1963;34:201-9.
11. **Boyd, R**. Mucogingival Considerations and their relationships to orthodontics. J Perio, 1978;49:67-76.
12. **Boyd R. L., Leggott P. J, Quinn R. S., Eakle W. S, and Chambers D** Periodontal implications of orthodontic treatment in adults with reduced or normal periodontal tissues versus those of adolescents AJO DO 1989;96:191-199
13. **Buckley Louis A.,** Relationship between malocclusion , gingival inflammation, plaque and calculus J Perio 1981;52(1):35-40
14. **Chung, Jung, Baik** Morphological characteristics of the symphyseal region in adult skeletal class III crossbite and openbite malocclusions. J Perio 2008;78(1):38-43
15. **Closs LQ, Branco P, Rizzatto SD, Raveli DB, Rösing CK** Gingival margin alterations and the pre-orthodontic treatment amount of keratinized gingiva Braz Oral Res 2007;21(1):58-63
16. **Coatum G, Behrents, Bissada,** The width of keratinized gingiva during orthodontic treatment Its significance and impact on periodontal status. J Perio 1981; 307-313
17. **Corelius M, Linder-Aronson S**, The relationship between the lower incisor inclination and variousreference lines. . Angle Orthod1976;46(2):111-118.
18. **Djeu G, Hayes C, Zawaideh S**. Correlation Between Mandibular Central Incisor Proclination and Gingival Recession During Fixed Appliance Therapy. Angle Orthod 2002;72:238–245.
19. **Dorfman** H. Mucogingival changes resulting from mandibular incisor tooth movement. AJO-DO 1978;74:286-97.

20. **Ellis E, McNamara JA Jr**. Components of adult Class III malocclusion. J Oral Maxillofac Surg. 1984 May;42(5):295-305.

21. **Erkan M, Pikdoken L, and Usumez S**. Gingival response to mandibular incisor intrusion AJO-DO 2007;132:143.e9-143.e13

22. **Evangelista K, Vasconcelos KF, Bumann A, Hirsch E, Nitka M, Silva M.A.G** Dehiscence and fenestration in patients with Class I and Class II Division 1 malocclusion assessed with cone-beam computed tomography. AJO-DO 2010;138:133.e1-133.e7

23. **Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong DJ, Wang HL.** Tissue biotype and its relation to the underlying bone morphology. J Periodontol. 2010 Apr;81(4):569-74.

24. **Geiger AM and Wasserman BH.** Relationship of occlusion and periodontal disease: Part IX – Incisor inclination and periodontal status. Angle Orthod 1976,Apr;46(2):99-110

25. **Geiger AM:** Mucogingival problems and the movement of mandibular incisors—a clinical review. AJO-DO, 1980;78:511-527

26. **Goaslind GD, Robertson PB, Mahan CJ, Morrison WW, Oslon JV**. Thickness of facial gingival, J Perio 1977;48(12) : 768-771

27. **Gracco A, Luca L, Bongiorno MC, Siciliani.G.** Computed tomography evaluation of mandibular incisor bony support in untreated patients. AJO-DO 2010;138:179-187

28. **Handelman C S**, The anterior alveolus; its importance in limiting orthodontic treatment and its influence on the occurance of iatrogenic sequelae. Angle Orthodontist 1996;66(2):95-110.

29. **Holdaway,R.A.** Changes in relationship of points A and B during orthodontic treatment. A JO-DO., 42:176, 1956.

30. **Holmes HD**, Tennant M, and Goonewardene MS. Augmentation of faciolingual gingival dimensions with free connective tissue grafts before labial orthodontic tooth movement:An experimental study with a canine model AJO-DO 2005;127:562-72

31. **Ingervall b, Jacobson U, Nyman S:** A clinical study of the relationship between crowding of teeth, plaque and gingival condition. J Clin. Periodont 1977;4:212

32. **Ishikawa.H, Nakamura.S, Iwasaki.H, Kitazawa.S, Tsukada.H, and Sato Y.** Dentoalveolar Compensation related to variations in sagittal jaw relationships. Angle Orthodontist:1999;69(6):534-538

33. **Ishikawa.H, Nakamura.S, Iwasaki.H, Kitazawa.S, Tsukada.H, and Chu.S**. Dentoalveolar compensation in negative overjet cases. Angle Orthodont: 2000 Apr;70(2):145-148

34. **Jacob S, Zade RM**. Width of attached gingiva in an Indian population: A descriptive study. Bangladesh Journal of Medical science, 2009;8(3)

35. **Katz RV.** An Epidemiologic Study of the Relationship Between Various States of Occlusion and the Pathological Conditions of Dental Caries and Periodontal Disease J Dent Res (3) :433-439, March 1978.

36. **Kloehn JS, Pfeifer JS:** The effect of orthodontic treatment on the periodontium. Angle Orthodont, 1974;44:127-134

37. **Krishnan, Ambili R, Davidovitch Z, and Murphy NC** Gingiva and Orthodontic Treatment Seminars in Orthod 2007;13:257-271

38. **Lang N P Löe H.** The Relationship Between the Width of Keratinized Gingival and Gingival Health Journal of Periodontol, 1972 Oct; 623 – 627

39. **Maynard, Oschsenbein**. Mucogingival problems, prevalence and therapy in children, Journal of Periodontol, 1975; 46:543-552

40. **McNamara JA Jr**. A method of cephalometric evaluation. AJO-DO 1984;86:449-69.

41. **Mehta P, Peng LL,** The width of the attached gingiva—Much ado about nothing? Journal of Dentistry 2010; 38 :517–525

42. **Melsen B , Allais D** : Factors of importance for the development of dehiscences during labial movement of mandibular incisors: a retrospective study of adult orthodontic patients. AJO-DO, 2005; 127:552-561

43. **Miyasato, Crigger and Egelberg**. Gingival condition in areas of minimal and appreciable width of keratinized gingiva. Jour Clin Perio 4:200-209, 1977

44. **Moriarty**,Mucogingival considerations for the orthodontic patient, Current Opinion in Periodontology 1996, 3:97-102.

45. **Muller HP, Eger T**. Gingival phenotypes in young male adults. J Clin Periodontol. 1997 Jan;24(1):65-71

46. **Okada N, Kasai K**. Relationship between mandibular tooth inclination and maxillofacial morphology using CT scanning. Nihon Univ J Oral Sci 1996;22:381-392

47. **Robinson SW, Spiedel TM, Isaacson RJ, Worms FW**. Amounts of soft tissue profile change produced by reduction of mandibular prognathism. 1972 july;42(4):227-235

48. **Richman C** Is Gingival Recession a Consequence of an Orthodontic Tooth Size and/or Tooth Position Discrepancy? “A Paradigm Shift” Compendium Of Continuing Education In Dentistry. 2010 aug, Volume 31, Issue 6

49. **SavithaB, VandanaKL**. Com parative assessment of gingival thickness using transgingival probing and ultrasonographic method. Ind J Dent Res 2005;16(4):135-139

50. **Silness J, Loe** H Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condtion. Acta Odontologica Scandinavica (1964); 22(1): 121-135

51. **Sperry TP, Speidel T.M, Isaacson R J, Worms F W**. The Role of Dental Compensations in the orthodontic treatment of Mandibular Prognathism. Angle Orthodont 1977;47(4):293-299.

52. **Tweed CH** Frankfort-Mandibular plane angle . in orthodontic diagnosis, classifica4tion, treatment planning, and prognosis AJO-DO 1946 april;32(4):175-230

53. **Tweed CH** Frankfort-Mandibular incisor angle . Angle orthod, 1954 july;24(3):121-169

54. **Tsunori M, Mashita M, Kasai K**. Relationship between facial types and tooth and bone characteristics of mandible obtained by CT scanning. Angle Orthod 1998;68(6):557-562

55. **Wennstrom J, Lindhe J**. Role of attached gingiva for maintenance of periodontal health. Healing following exicisional and grafting procedures in dogs. Journal of Clinical Periodontology 1983 March;10(2):311–28.

56. **Wennstrom JL**. Lack of association between width of attached gingiva and development of soft tissue recession, a 5-year longitudinal study,J Clin Perio, 1987; 14: 181-184.

57. **Wennström JL**. Mucogingival considerations in orthodontic treatment. Seminars in Orthod. 1996 Mar;2(1):46-54

58. **Wingard CE, Bowers GM**. The effects on facial bone from facial tipping of incisors in monkeys. J Periodontol 1976;47:450-4.

59. **Yagci A, Veli I, Uysal T, Ucar Fi, Ozer T, Enhos S**. Dehiscence and fenestration in skeletal Class I, II, and III malocclusions assessed with cone-beam computed tomography. Angle Orthod.2011 june 22 online issue.

60. **Yamada C, Kitai N, Kakimoto N, Murakami S, Furukawa S, Takada K** Spatial Relationships between the Mandibular Central Incisor and Associated Alveolar Bone in Adults with Mandibular Prognathism Angle Orthodont, 2007; 77 (5):766-772

61. **Yared KF, Zenobio EG, Pacheco W**. Periodontal status of mandibular central incisors after orthodontic proclination in adults. AJO-DO 2006;130:e1–8.

62. **Yu Q, PanX, Ji G, Shen G**. The Association between Lower Incisal Inclination and Morphology of the Supporting Alveolar Bone — A Cone-Beam CT Study. International Journal of Oral Science, 1(4): 217–223, 2009

63. **Zachrisson BU, Alnaes L:** Periodontal condition in orthodontically treated and untreated individuals—I. Loss of attachment, gingival pocket depth and clinical crown height. Angle Orthod 1973;43:402-411

64. **Zachrisson S, Zachrisson BU**: Gingival condition associated with orthodontic treatment. Angle Orthod 1972;42:26-34.

65. **Zachrisson BU.** Orthodontics and Periodontics, In Lindhe J, Clinical periodontology and implant dentistry, 3rd edition 1998,:741-793

Table -1a One way ANOVA to compare mean values of Width of attached gingiva in relation to skeletal patterns

Width of Attached gingiva	N	Mean in mm	Std. Dev	F-Value	P-Value (<0.05)
Class I	50	1.17	0.374	5.680	0.004
Class II	50	1.40	0.467		
Class III	50	1.14	0.393		

Table -1b Tukey HSD Post Hoc tests for multiple pair wise comparisons

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	P-Value (<0.05)
Width of Attached gingiva	Class I	Class II	-0.225	0.019
		Class III	0.029	0.934
	Class II	Class III	0.254	0.007

Table -2a One way ANOVA to compare mean values of Width of attached gingiva in relation to mandibular incisal inclination

Width of Attached gingiva		N	Mean in mm	Std. Deviation	F-Value	P-Value (<0.05)
Width	< 85º	23	0.900	0.242	10.676	<0.001
	85º - 95º	28	1.175	0.354		
	>95º	99	1.328	0.438		

Table -2b Tukey HSD Post Hoc tests for multiple pair wise comparisons

Dependent Variable	(I) IMPA Code	(J) IMPA Code	Mean Difference (I-J)	P-Value (<0.05)
Width	< 85º	86º - 95º	-0.275	0.045
		>95º	-0.428	<0.001
	85º - 95º	>95º	-0.153	0.179

Table -3a One way ANOVA to compare the mean values of width of attached gingiva in relation to FMA Groups

FMA group	N	Mean in mm	Std. Dev	F-Value	P-Value (<0.05)
Low angle (<22º)	46	1.271	0.376	3.260	0.241
Avg angle (22º-28º)	66	1.228	0.356		
High angle (>28º)	38	1.137	0.435		

Table – 3b Tukey HSD Post Hoc Tests for Multiple Comparisons

(I) FMA Code	(J) FMA Code	Mean Difference (I-J)	Std. Error	P-Value (<0.05)
Low angle (<22º)	Average angle (22º-28º)	-0.143	0.085	0.495
	High angle (>28º)	-0.134	0.082	0.282
Average angle (22º-28º)	High angle (>28º)	-0.091	0.081	0.220

Table -4a One way ANOVA to compare mean values of Thickness of attached gingiva in relation to skeletal patterns

Thickness of Attached gingiva	N	Mean in mm	Std. Dev	F-Value	P-Value (<0.05)
Class I	50	1.10	0.389	8.441	<0.001
Class II	50	1.19	0.447		
Class III	50	0.88	0.315		

Table -4b Tukey HSD Post Hoc tests for multiple pair wise comparisons

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	P-Value (<0.05)
Thickness of Attached gingiva	Class I	Class II	-0.088	0.494
		Class III	0.221	0.014
	Class II	Class III	0.309	<0.001

Table -5a One way ANOVA to compare mean values of Thickness of attached gingiva in relation to mandibular incisal inclination

Thickness of Attached gingiva		N	Mean in mm	Std. Deviation	F-Value	P-Value (<0.05)
Thickness	< 85º	23	0.748	0.405	9.696	<0.001
	85º - 95º	28	1.000	0.290		
	>95º	99	1.139	0.402		
	Total	150	1.056	0.406		

Table -5b Tukey HSD Post Hoc tests for multiple pair wise comparisons

Dependent Variable	(I) IMPA Code	(J) IMPA Code	Mean Difference (I-J)	P-Value (<0.05)
Thickness	< 85º	85º – 95º	-0.252	0.059
		>95º	-0.391	<0.001
	85º - 95º	>95º	-0.139	0.212

Table – 6a One way ANOVA to compare the mean values of thickness of attached gingiva in relation to FMA

FMA group	N	Mean in mm	Std. Dev	F-Value	P-Value (<0.05)
Low angle (<22º)	46	1.126	0.376	0.768	0.466
Avg angle (22º-28º)	66	1.034	0.335		
High angle (>28º)	38	1.030	0.513		

Table – 6b Tukey HSD Post Hoc Tests for Multiple Comparisons

(I) FMA Code	(J) FMA Code	Mean Difference (I-J)	Std. Error	P-Value (<0.05)
Low angle (<22º)	Average angle (22º-28º)	0.003	0.078	0.999
	High angle (>28º)	-0.093	0.089	0.554
Average angle (22º-28º)	High angle (>28º)	-0.096	0.083	0.480

Table - 7 Correlations between the type of skeletal pattern and width & thickness of attached gingiva

Variables	n	Correlation value	P-Value (<0.05)
Class I vs Width	50	0.135	0.350
Class I vs Thickness	50	-0.535	<0.001
Class II vs Width	50	-0.099	0.495
Class II vs Thickness	50	0.203	0.157
Class III vs Width	50	0.352	0.012
Class III vs Thickness	50	0.297	0.036

Table - 8 Correlation between IMPA and width & thickness of attached gingiva

IMPA range		Width		Thickness	
	n	Correlation value	P-Value (<0.05)	Correlation value	P-Value (<0.05)
< 85º	23	0.597	0.003	0.391	0.0072
85º - 95º	28	0.669	<0.001	0.049	0.806
>95º	99	-0.105	0.297	0.017	0.870

Table – 9 Correlation between FMA and width & thickness of attached gingiva

FMA Group		Width of AG		Thickness	
	n	Correlation value	P-Value (<0.05)	Correlation value	P-Value (<0.05)
Low angle (<22º)	46	0.345	0.019	0.118	0.436
Average angle (22º-28º)	66	0.068	0.589	0.148	0.235
High angle (>28º)	38	0.148	0.376	-0.262	0.111

Table - 10 Comparison between Skeletal pattern, IMPA and FMA in relation to width & thickness of attached gingiva

	Correlation value(r)	P-Value (<0.05)
IMPA vs Width of AG	0.273	>0.05
ANB vs Width of AG	0.257	
FMA vs Width of AG	0.255	
IMPA vs Thickness of AG	0.324	>0.05
ANB vs Thickness of AG	0.316	
FMA vs Thickness of AG	0.289	

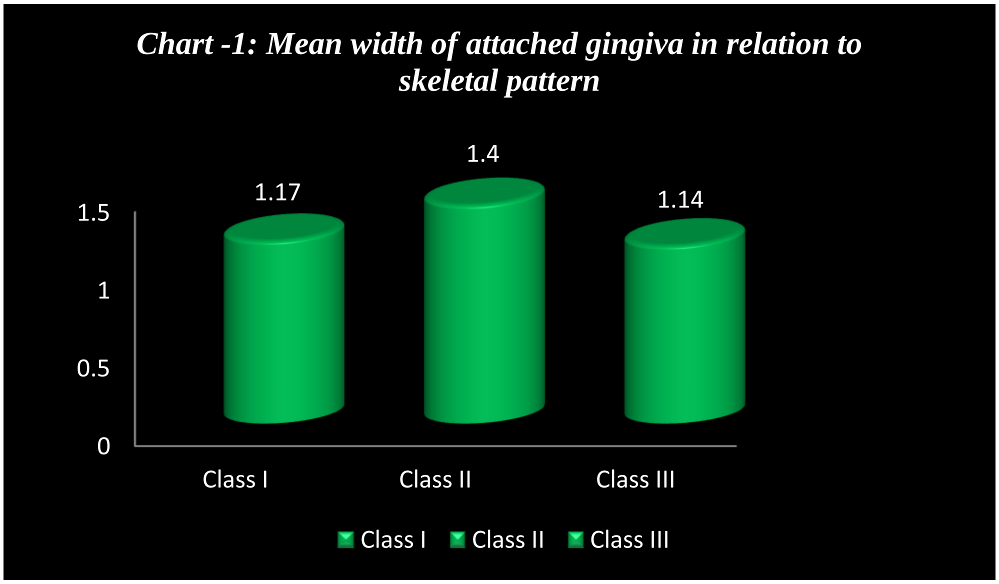


Chart -1: Mean width of attached gingiva in relation to skeletal pattern
1.17
1.4
1.14
1.5
1
0.5
0
Class I
Class II
Class III
Class I
Class II
Class III

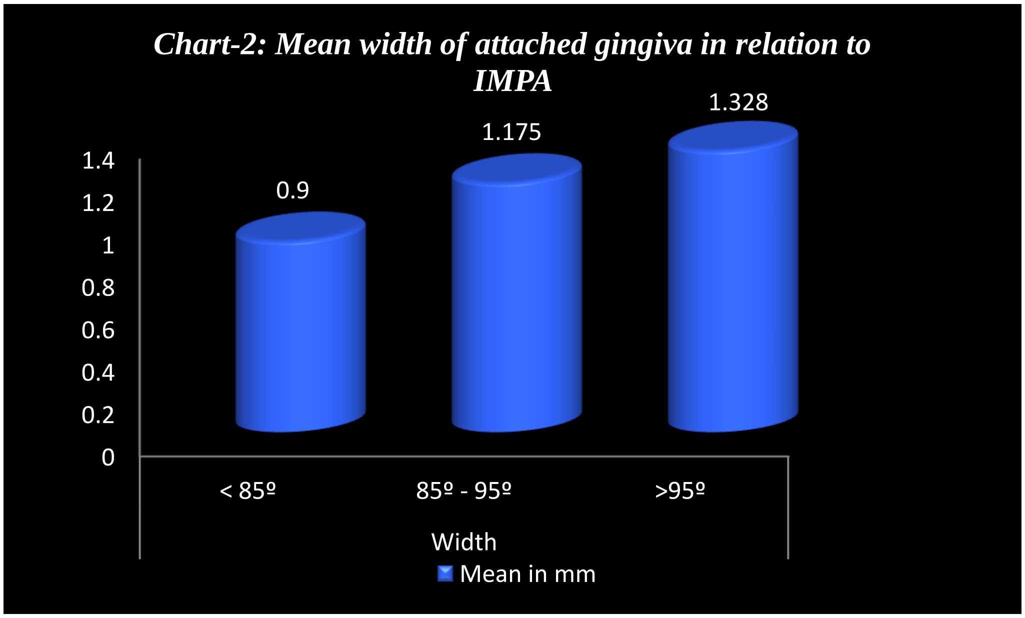


Chart-2: Mean width of attached gingiva in relation to IMPA
1.328
1.175
0.9
1.4
1.2
1
0.8
0.6
0.4
0.2
0
< 85º
85º - 95º
>95º
Width
Mean in mm

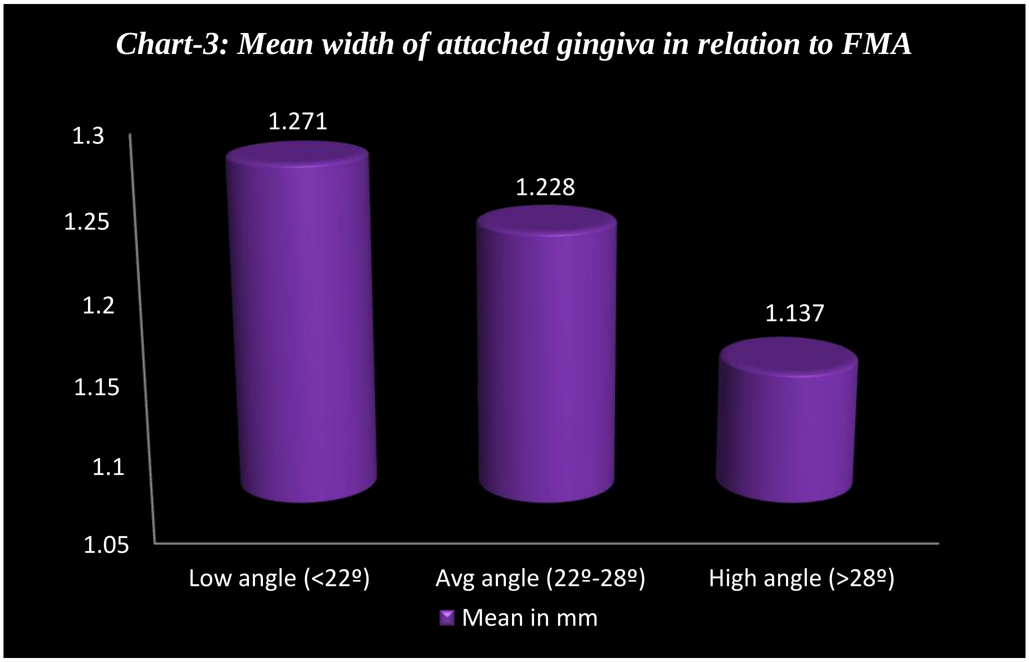


Chart-3: Mean width of attached gingiva in relation to FMA
1.3
1.25
1.2
1.15
1.1
1.05
1.271
1.228
1.137
Low angle (<22º)
Avg angle (22º-28º)
High angle (>28º)
Mean in mm

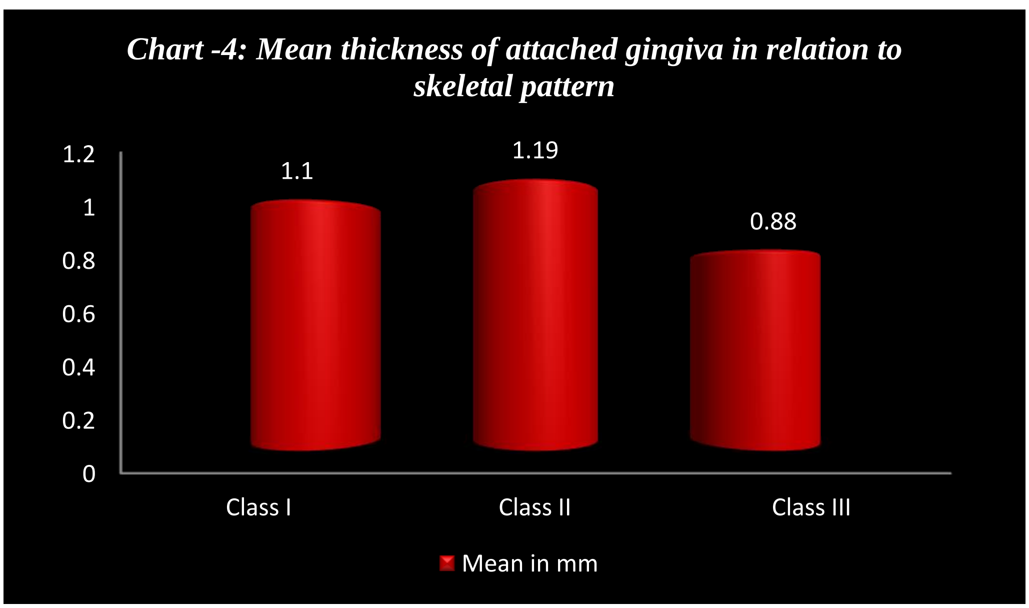


Chart -4: Mean thickness of attached gingiva in relation to skeletal pattern
1.2
1
0.8
0.6
0.4
0.2
0
1.1
1.19
0.88
Class I
Class II
Class III
Mean in mm

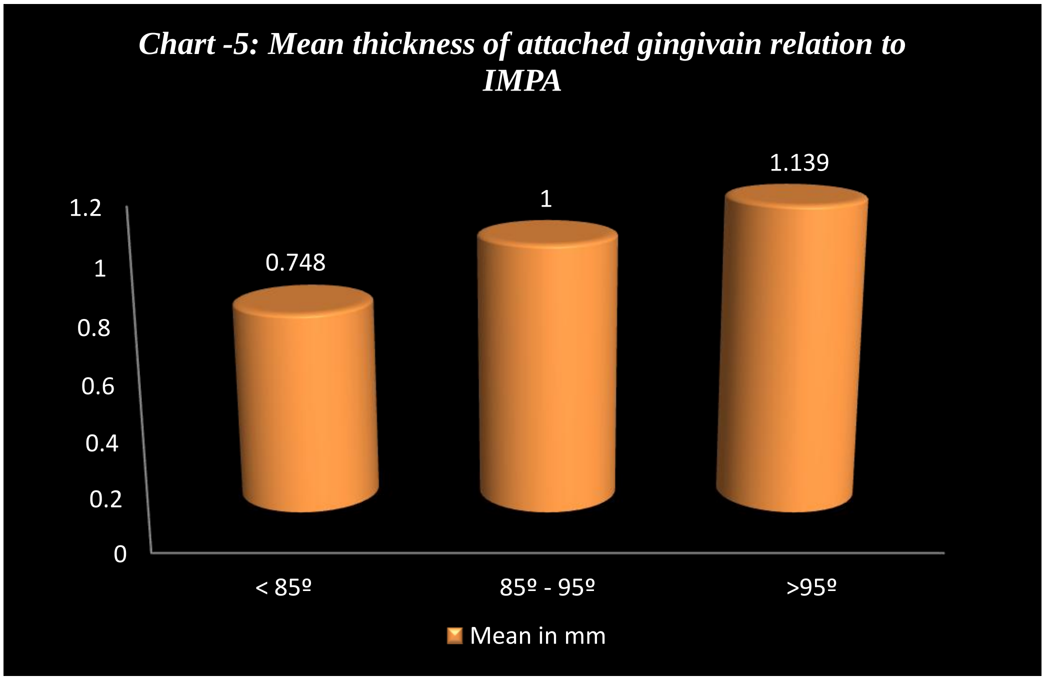


Chart -5: Mean thickness of attached gingivain relation to IMPA
1.2
1
0.8
0.6
0.4
0.2
0
0.748
1
1.139
< 85º
85º - 95º
>95º
Mean in mm

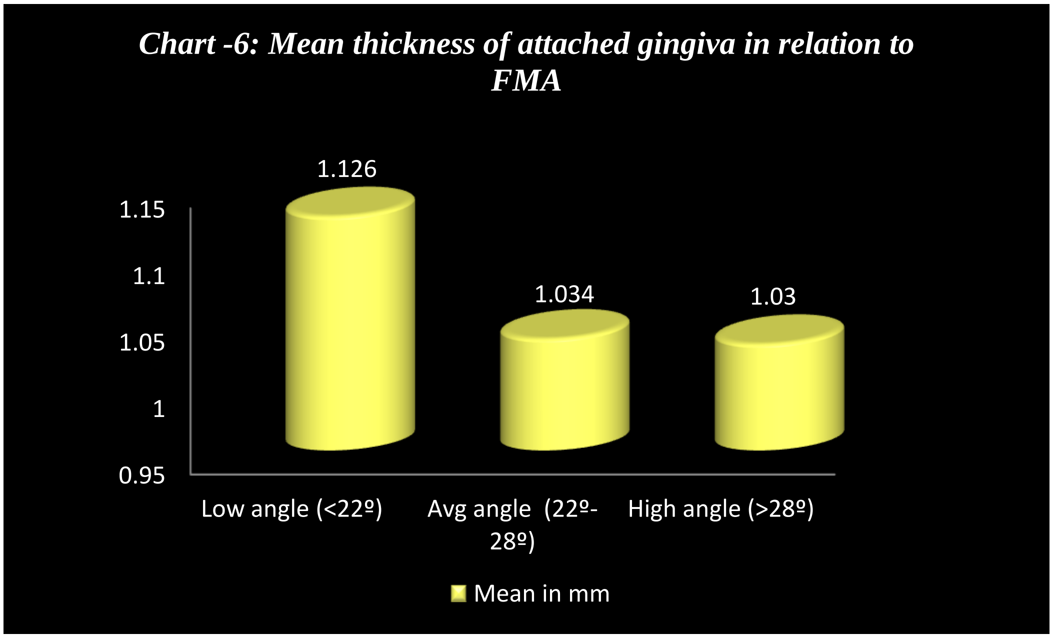


Chart -6: Mean thickness of attached gingiva in relation to FMA
1.15
1.1
1.05
1
0.95
1.126
1.034
1.03
Low angle (<22º)
Avg angle (22º-28º)
High angle (>28º)
Mean in mm

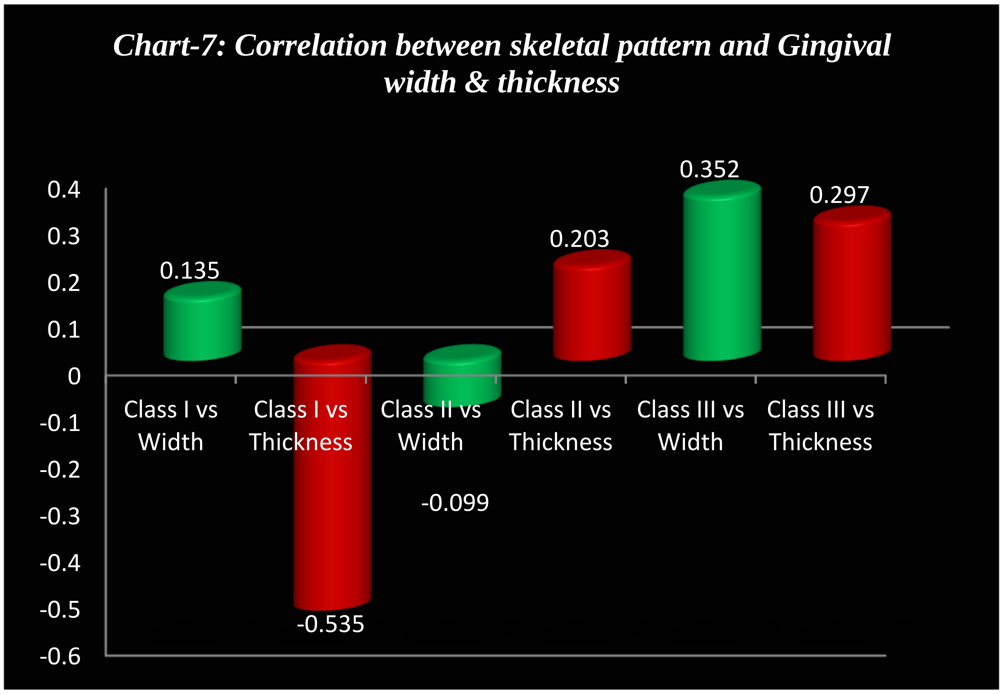


Chart-7: Correlation between skeletal pattern and Gingival width & thickness
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0.135
-0.535
-0.099
0.203
0.352
0.297
Class I vs Width
Class I vs Thickness
Class II vs Width
Class II vs Thickness
Class III vs Width
Class III vs Thickness

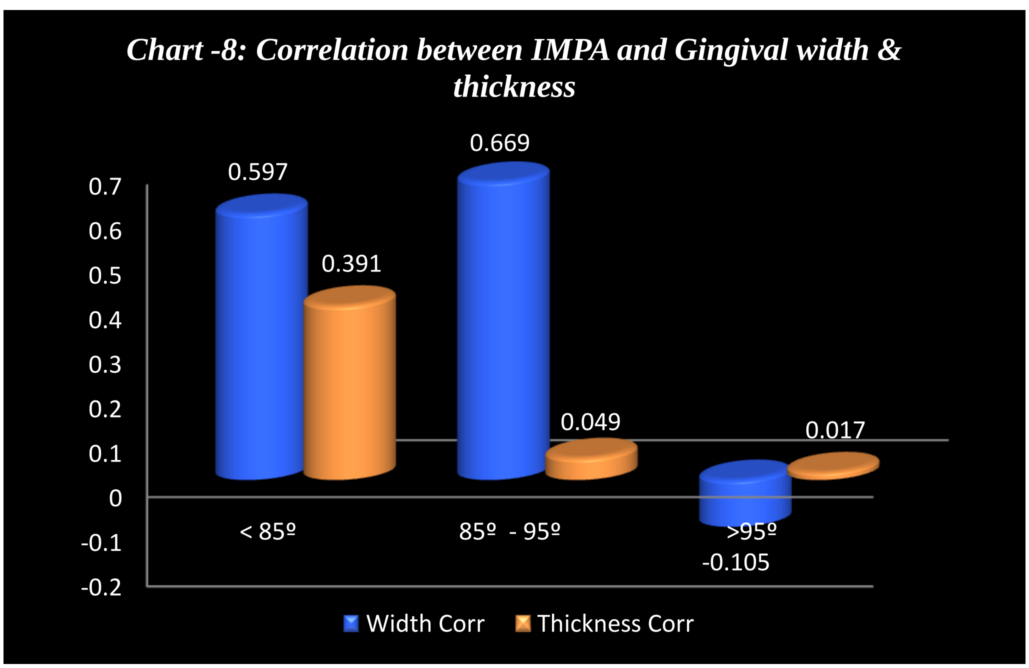


Chart -8: Correlation between IMPA and Gingival width & thickness
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0.597
0.391
0.669
0.049
-0.105
0.017
< 85º
85º - 95º
>95º
Width Corr
Thickness Corr

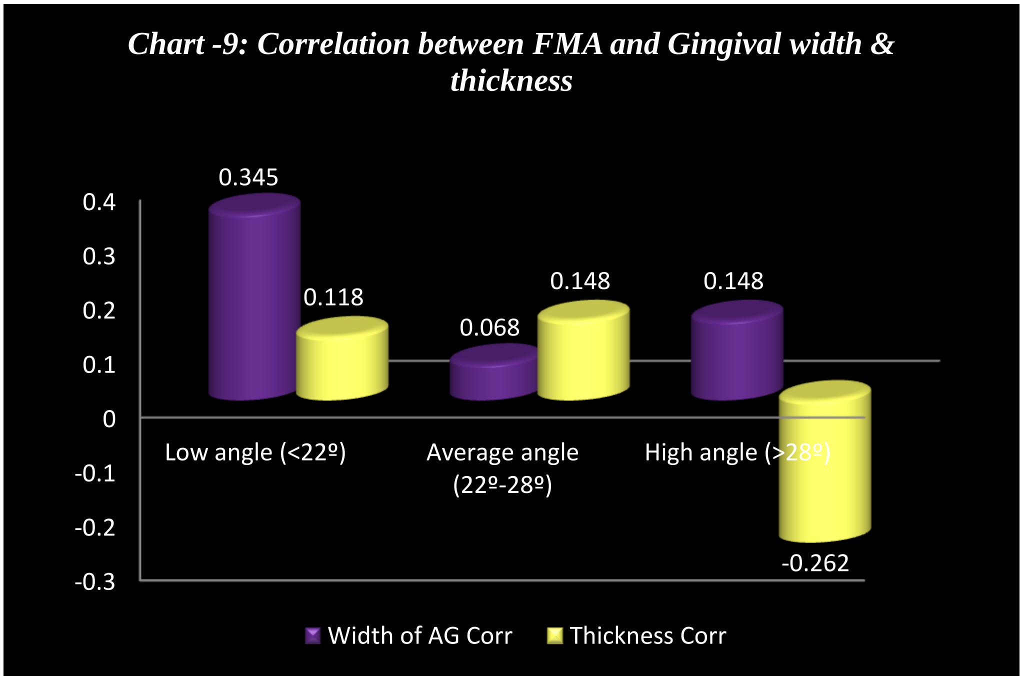


Chart -9: Correlation between FMA and Gingival width & thickness

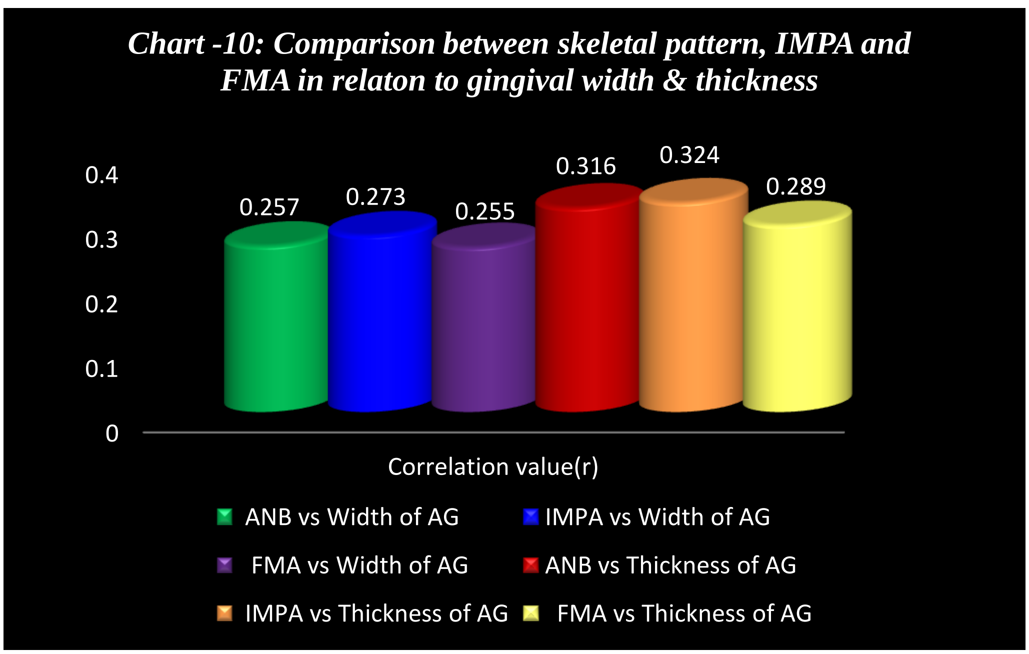
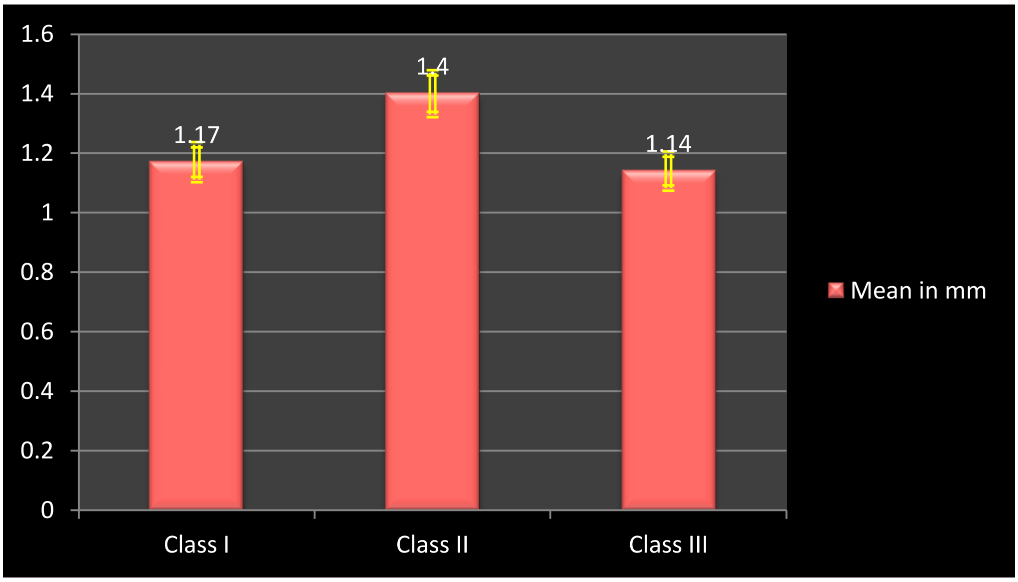


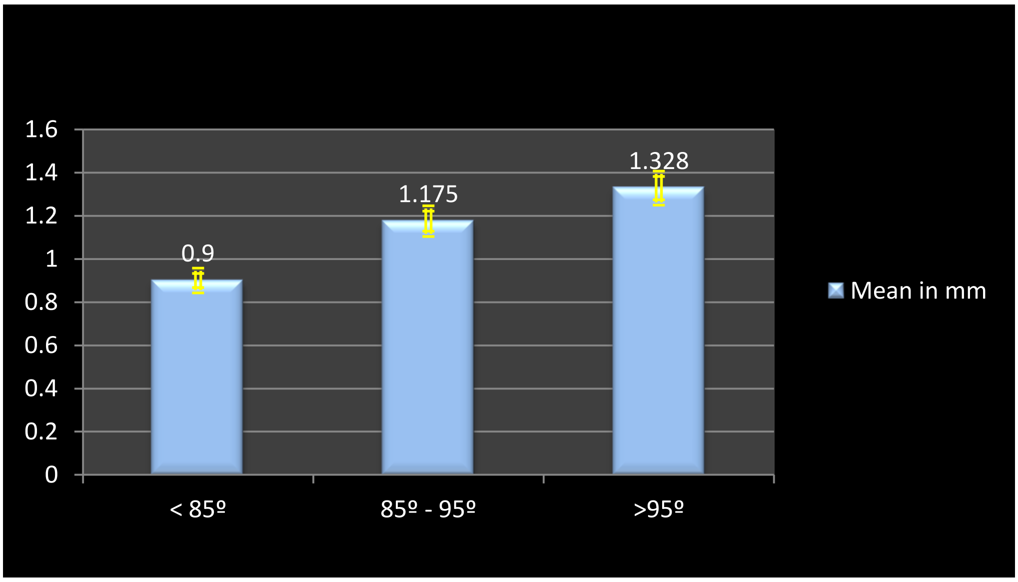
Chart -10: Comparison between skeletal pattern, IMPA and FMA in relaton to gingival width & thickness

ASSESSMENT OF WIDTH OF ATTACHED GINGIVA

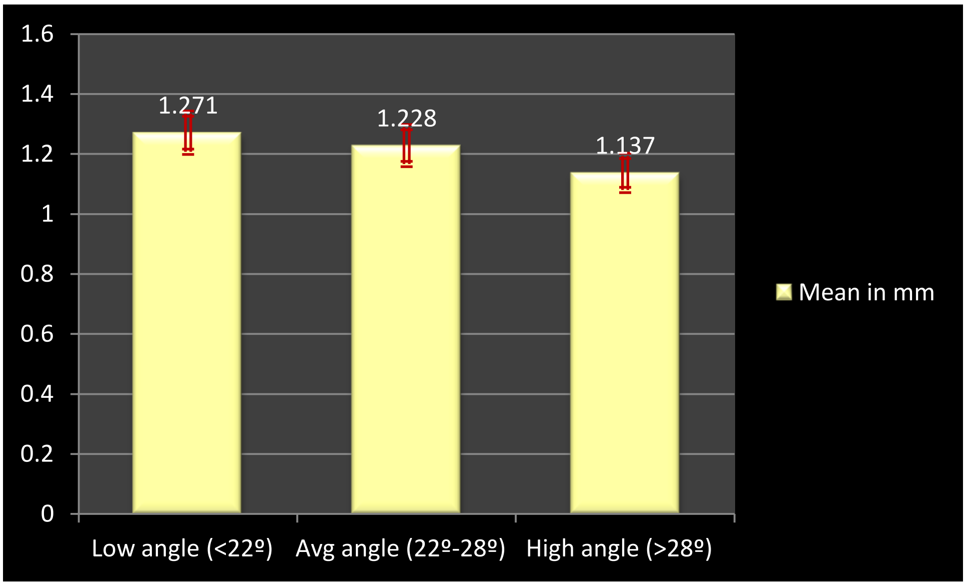
Graph 1 Mean ± SD width of attached gingiva in relation to skeletal pattern



Graph 2 Mean ± SD width of attached gingiva in relation to IMPA

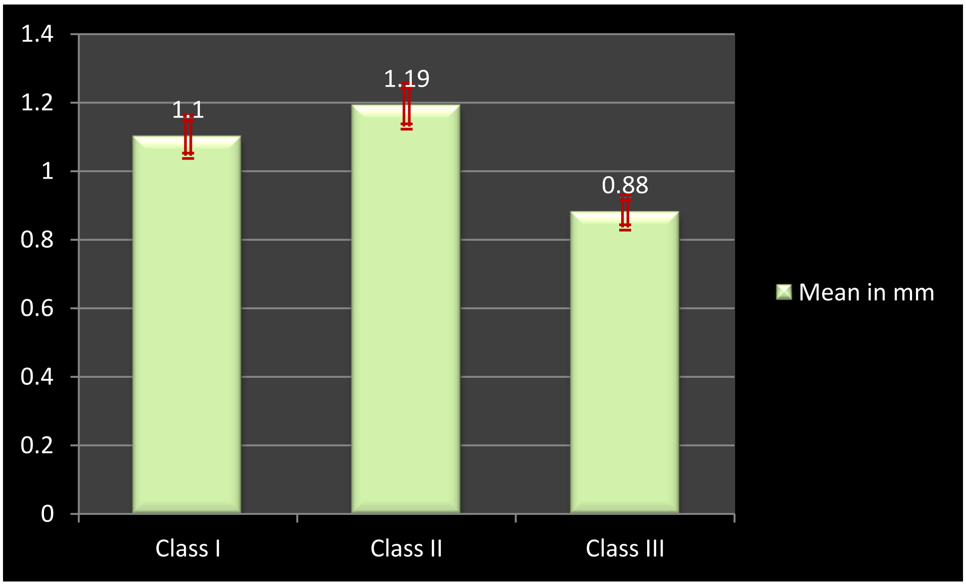


Graph 3 Mean ± SD width of attached gingiva in relation to FMA

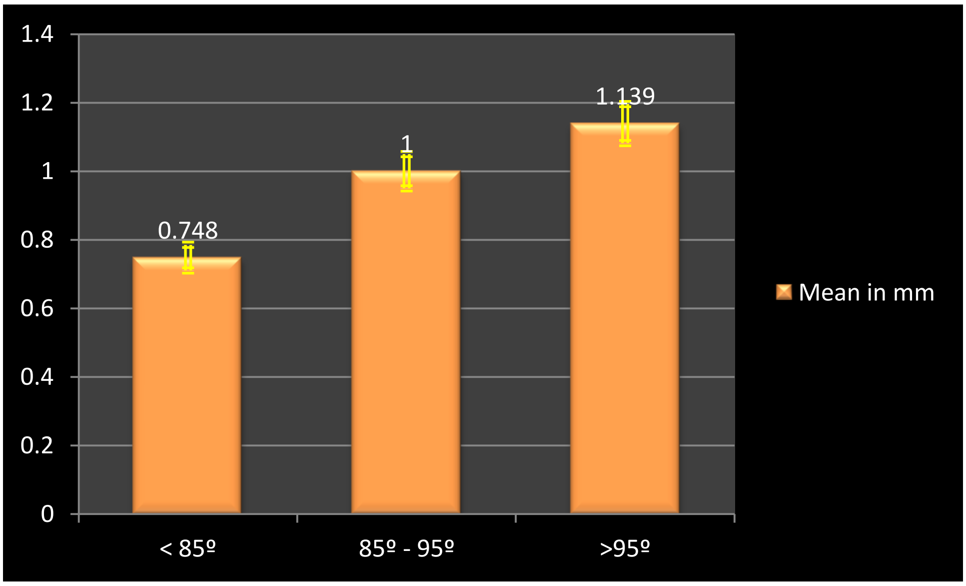


ASSESSMENT OF THICKNESS OF ATTACHED GINGIVA

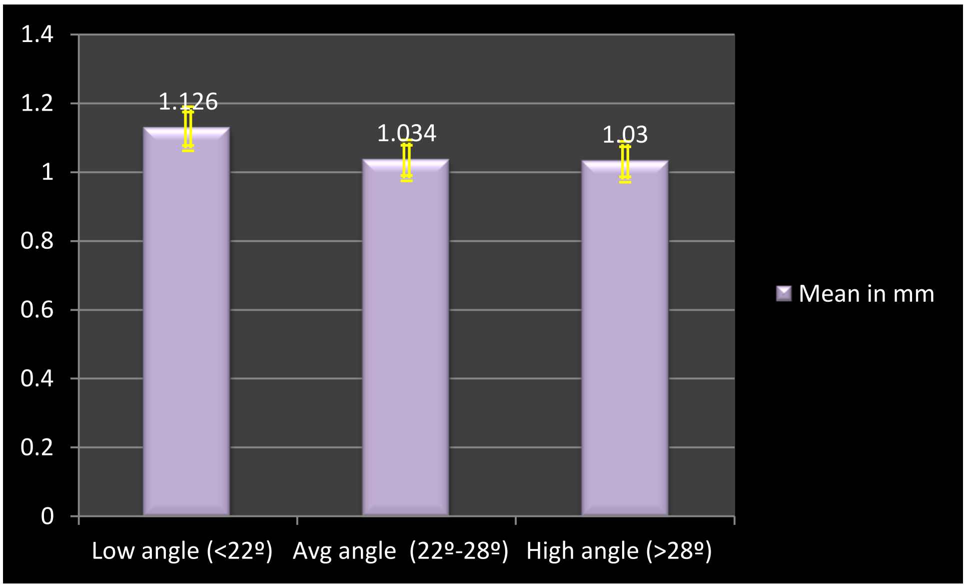
Graph 4 Mean ± SD thickness of attached gingiva in relation to skeletal pattern



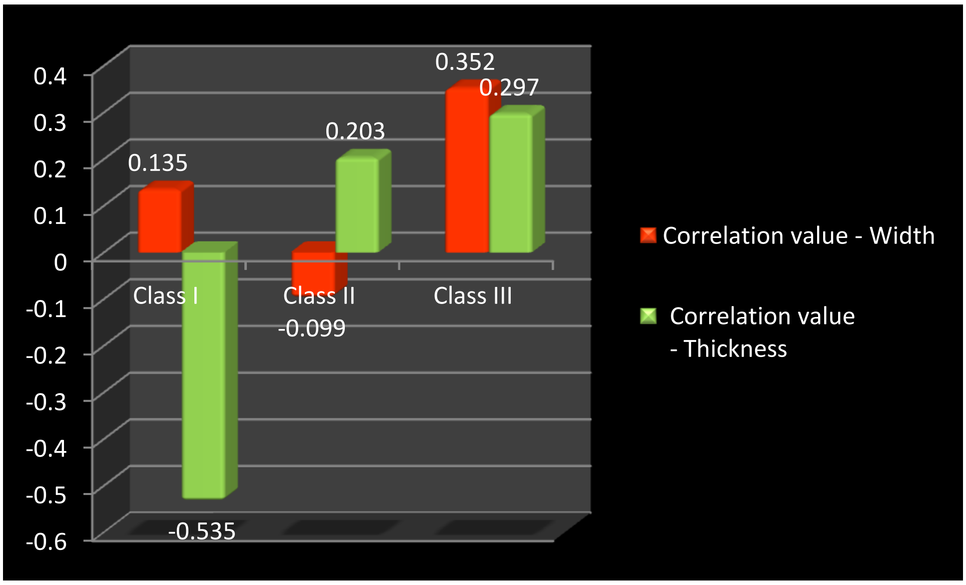
Graph 5 Mean ± SD thickness of attached gingiva in relation to IMPA



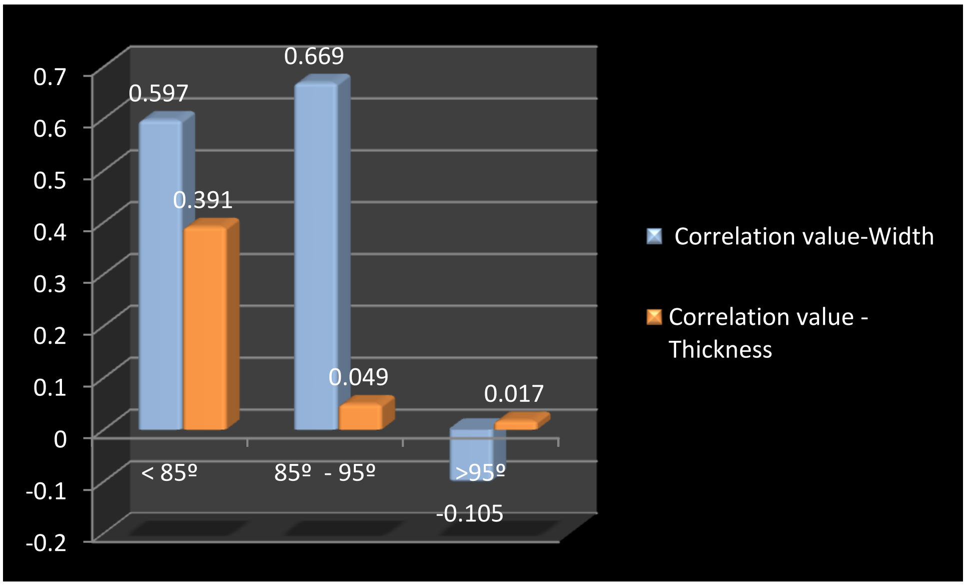
Graph 6 Mean ± SD thickness of attached gingiva in relation to FMA


1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.126
1.034
1.03
Mean in mm
Low angle (<22º)
Avg angle (22º-28º)
High angle (>28º)

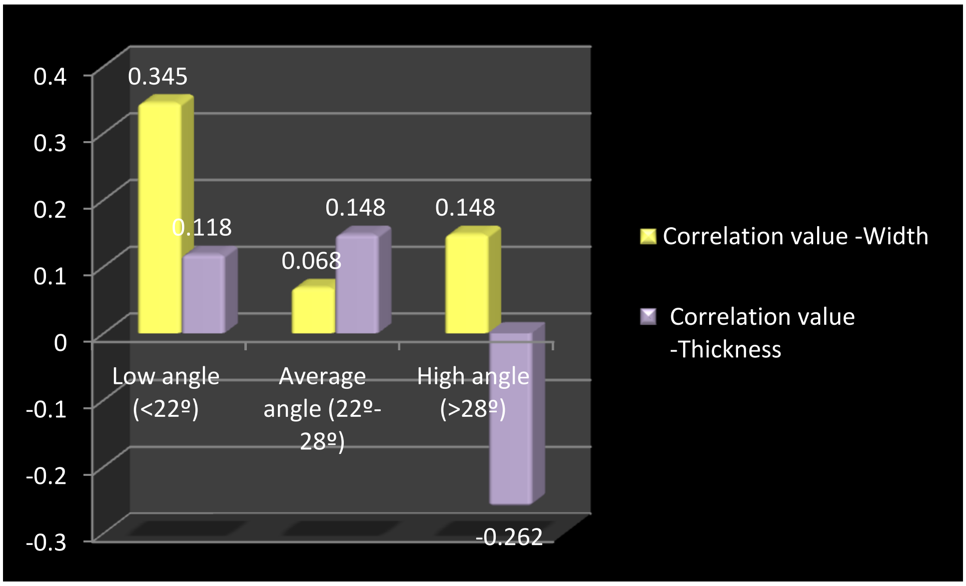
Graph 7 Correlation between skeletal pattern and width & thickness of attached gingiva



Graph 8 Correlation between IMPA and width & thickness of attached gingiva



Graph 9 Correlation between FMA and width & thickness of attached gingiva



Graph 10 Comparison between skeletal pattern, IMPA and FMA in relation to width & thickness of attached gingiva